Keep hackers out with a firewall!

SILICON CHIP

JUNE 2002
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PROJECTS TO BUILD - SERVICING - COMPUTERS - VINTAGE RADIO - AUTO ELECTRONICS

NASA's Helios:
taking winged flight to record heights

0-80A DC Vehicle Ammeter

Power Supply for Stepper Motors

Remote, Motorised Volume Control

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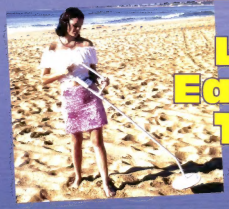
DSE 2002 CATALOG



Low cost, Easy-to-build Treasure Hunter!

To understand why $6,843 is a fair price to pay for VAF kit speakers, read 580 words from a violinist who can't use a screwdriver.

The following is an excerpt from a review which appeared in Audio Video Lifestyle Consumer Guide '99 by Sian O'Neale.

"Phillip Vafiadis is the creative talent behind the brand and his aim with VAF Research is to market kit loudspeakers of uncompromising quality at the serious end of the hi-fi market.

The VAF range is priced from $312 a pair right up to $8,863 a pair*, so we're talking serious money here for serious equipment.

We at AVL magazine have been particularly impressed with DC-X series.

These kit loudspeakers are not the standard packages from consumer electronics stores. In fact, you won't find these products in any store. The company prefers to cut out the middle-men and save buyers money, so every product is available factory-direct.

The VAF Signature series includes the Signature 1-66 and 1091 loudspeakers. Taking delivery of the 120kg 1-66 floorstanding speakers is something of an experience; I have never seen such an imposing crate for a pair of loudspeakers before. Fortunately my brother Crispin is capable with the screwdriver and we took out the massive 1-66s. You will need quite a bit of muscle and help to unpack these speakers and get them where you want them. The engineering and attention to finish that has gone into these fully assembled VAF Research 1-66s is simply awesome.

These elegant but powerful looking loudspeakers come with removable velcro attached grilles in a 3-way design; a 210mm hard paper bass driver with solid copper phase plugs and a 25mm double chamber sonotex dome tweeter with a pure silver wire voice coil. Turn the speakers around and you have very high quality gold plated binding posts which allow for bi-wiring and tri-wiring.

The same meticulous attention to detail and build quality also goes into the smaller 1-91 models, three of which are presented as left and right rear surrounds and a centre channel speaker for home theatre use (which has a custom-designed grille for a centre channel speaker). But the 1-91 loudspeakers have been designed to also perform as high quality studio monitors with the same superb sound as the 1-66s.

The speakers were designed to be used close to a rear wall and that's how customers use them, ideally 15cm-40cm from the nearest wall. But I think the speakers sound better when they can breathe more easily. Find the right position for the room and you will be richly rewarded.

The big VAFs deliver a stunning soundstage which is wonderfully insightful and involving. Large scale orchestral works have a level of depth and accuracy that only the best loudspeakers can manage.

As a violinist, I am often left unimpressed with the sound of the violin through so many loudspeakers (even high-end models), but here the presentation is accurate and engrossing. Instrument separation between different members of the orchestra is faultless.

This is particularly obvious when listening to Hans Zimmer's evocative soundtrack for The Thin Red Line in which quiet, gentle music provides so much power and atmosphere.

As a system for home theatre, together with the smaller satellite 1-91s, VAF has assembled an incredible system. Bass extension from the 1-66s is awesome; deep and thrilling, which is ideal for action blockbusters such as Speed, Twister or Titanic (you don't just watch the ship sink - you feel it through the floorboards). The centre channel speaker locks dialogue firmly into place and steers the sound with maximum impact; dialogue in Speed comes across as frantic as the driving. Full marks."

* Figures amended to reflect current pricing.

For the entire transcript of this review or information on our 14 models contact VAF Research and ask for your copy of "What the Critics Say". Free call 1800 818 882. Email vaf@vaf.com.au or surf www.vaf.com.au

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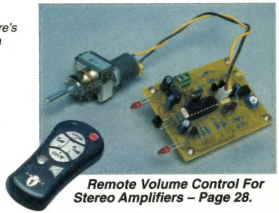

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Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc.(Hons.)

Technical Staff
John Clarke, B.E.(Elec.)
Peter Smith
Ross Tester
Jim Rowe, B.A., B.Sc, VK2ZLO
Rick Walters

Reader Services
Ann Jenkinson

Advertising Enquiries
Leo Simpson
Phone (02) 9979 5644
Fax (02) 9979 6503

Regular Contributors
Brendan Akhurst
Rodney Champness, VK3UG
Julian Edgar, Dip.T.(Sec.), B.Ed
Mike Sheriff, B.Sc, VK2YFK
Philip Watson, MIREE, VK2ZPW
Bob Young

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PUBLISHER'S LETTER

Viruses on emails are a huge problem

This month we are running a feature on firewalls for your computer. This is a subject which is very close to my heart; not because I like it but because I am constantly aware that we are under attack. Literally.

It is a sad fact that anyone and everyone who has their computer connected to the Internet is constantly being scanned for weaknesses by people who can only be described as parasites. If you read nothing else in this issue, make sure you read the article on firewalls beginning on page 16. Read it and act upon it because unless you are doing everything advocated in the article, your computer and your files are extremely vulnerable.

Maybe you don't use the Internet but just have email. But if you are sending and receiving email from your computer, you are still connecting to the Internet. You are still likely to be under attack from the mind-boggling and constantly growing armada of viruses and other nasties out there. Every day we get another virus attack and very occasionally they get through the chinks, even though we update virus definitions as soon as they are available.

It beats me why there are apparently so many people in the world who get such a thrill from creating and propagating viruses. It is such an act of bastardry - nothing less. We have already had the hard disk on one of our machines trashed by a virus.

Make no mistake. Sooner or later some large (and many a small) company is going to be so badly affected by a virus that their records will be destroyed and they will go out of business. When that occurs, a lot of people will lose heaps of money and their jobs. Is that the thrill that these mental defectives are hoping for?

I suppose when that happens, the authorities will then start to get serious about hunting down these people. Sure, the great majority of viruses come from overseas but then maybe the government should start applying pressure to those countries which have the greatest number of parasites.

Do I sound paranoid? I am. Even though we have a firewall, we still make sure that the modem is turned off at night. After all, if a trojan program becomes embedded in your system and it is turned on all the time, there is nothing to stop it dialling out at night and squirting your files out to who knows where.

Just remember, the Internet is a fantastic place but it is also very dangerous. If your computer is unprotected and you have sensitive files on it, you could be in trouble. And you may never know . . .

Leo Simpson

Queensland Electrical Safety Review

Finally, an update: the Queensland Government has carried out their review of electrical safety regulations. They have ignored our suggestions for an introduction of wiring regulations similar to that in New Zealand. They are proposing more licensing, not less. They have not learned anything . . .

You can check their 33-page document on **www.eso.qld.gov.au**
To make a submission: email **mark.dearlove@qld.gov.au**

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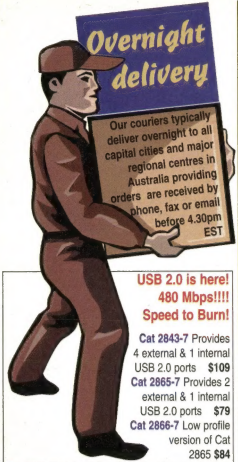

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SILICON CHIP MAILBAG

Focus on solar energy payback is wrong

Congratulations on your cover and articles relating to solar energy in the March 2002 issue. Although I disagree with a number of points in the editorial and Ross Tester's effort I am pleased to see the profile of appropriate technology raised.

Firstly and most importantly I will address the 'Payback' issue. Using your logic, I would not purchase any product unless its purchase price was 'repaid' by the product's operation or use during a set period of time. If I applied this same logic to buying a TV, boat, jet ski or caravan, for example, than I would most certainly never get my money back.

My payback occurred the day I purchased the system. I supported one of the few successful electronics industries left in Australia and all the people it employs. I supported a growing solar HW industry which exports the majority of its output and employs people in manufacturing, export and installation of their products.

I have a 6-module system generating about 2kWh/day in sunny weather. It provides lighting and ceiling fan operation most nights in a 4-bedroom brick veneer home using an Australian-made 1.6kW sinewave inverter, 24V regulator and 24V 215A.h battery bank. I also have a 305-litre Australian-made solar HWS saving about 8kWh/day.

Should the power fail, I can cook with gas, have a hot shower and watch a DVD until it comes back on. It will reduce my electricity bill every day the sun shines. Personal payback achieved.

The inset "Better Ways to Save Greenhouse Gases" was well meaning but only got it about half right. Buying a new car is OK if you can afford it and certainly avoid a 4WD if you don't need one. I support the points regarding new fridges, freezers, aircons and a solar HWS also. However, for a large number of people purchasing new goods of any type is not an option.

So what is cheap and easy and has a significant effect on energy consumption? The off switch is number one on my list. I found that by turning off small energy consumers such as TVs, VCRs, microwaves and plugpack-operated devices when not in use, I saved about 1.5kWh/day. Before my solar HWS arrived I fitted a 7-day timer to the electric unit and reduced its on-time to a few hours per day.

I also turned the thermostat down to 55°C. Around 2kWh/day can be saved easily this way. The saving of a few percentage points nationwide is a big number of kWh that never needs to be generated.

Brian Bartlett,
Rockhampton, Qld.

Fix for LCD in Parallel Port PIC Programmer

I recently assembled the Parallel Port PIC Programmer from the March 2001 issue and it works well. However, I did encounter a problem with the Liquid Crystal Display Adapter which did not work. I dissected the code. It worked in the simulator software available from MICROCHIP.COM (free) but the hardware refused to co-operate. Focusing on the "LCDBUSY" subroutine in the program led to a detailed investigation of the LCD display response time to the instruction

"MOVF LCD_DATA,W"

in this subroutine.

The PIC did not read this correctly but read some arbitrary data after executing this loop many (?) times. The trick I remembered was to re-read the peripheral several times if necessary. This fixes the problem and the program and hardware are working now. To summarise, if you have problems getting the LCD display project to work, find and change:

MOVF LCD_DATA,W
to
MOVF LCD_DATA,W
MOVF LCD_DATA,W

in subroutine "LCDBUSY", then "rebuild" the program and write it to the PIC using the Programmer. Hopefully all will be well.

Thanks for a great magazine and may you never run out of projects.

Frank Winter, VK4BLF,
via email.

USB LED lamp follow up

I was delighted to see a great writeup of my Itsy-Bitsy USB Lamp in the March 2002 issue of SILICON CHIP. The diagrams were, as always, quite magnificent. In fact several outside comments arrived along the lines of "it's good to see universities doing some simple, cheap, but clever *real world* projects that normal people can understand and need"! The ultimate

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compliment must however be from Jaycar, since I note they've already rustled it up as a kit. Yah!

An obvious enhancement (since adopted here) is to recognise that light will also be needed when the PC is switched off. In fact, this is often where it's REALLY needed – fiddly cable, jumper and connector setups normally occur when powered down. USB ports only supply 5V when the PC is on, of course.

What we've done here is to take a one-metre M-F USB cable, make a somewhat longer "Itsy Bitsy" with almost all this but use the otherwise wasted female part, along with some insulated crocodile clips/battery snaps and another dropping resistor (or 7805 3-terminal regulator) and connect to a normal 9V battery. Trials show that at least 10 hours bright light results – depending on the battery type but a 7805 allows a 12V SLA battery to be connected instead, giving days of bright lighting.

I've even experimented with a small rechargeable battery (ex-motherboard 3.6V nicad) in the itsy bitsy line, that would charge whenever the USB lamp is plugged in. Only about two hours light is available from this, however.

Stan Swan,
Massey University, NZ.

Diesels may be more economical than cars

Ross Tester's recommendation, in the March 2002 article on solar power, about getting rid or your "full-size 4WD" to save fuel compared to say, a Ford Falcon, cannot go unchallenged. I own one of each and my Nissan Patrol Turbo Diesel truck beats my Falcon by a long margin around town. My Falcon can easily use as much as 18l/100km on short runs, which is what I do most of the time. The Patrol will never use more than 14 and mostly about 12.5l/100km under the same conditions! On the freeway, the Falcon will use less than the truck but not a lot less.

Horst Leykam,
via email.

Solar panels have a long energy payback

I read with interest your editorial and article on solar power in the March 2002 issue with reference to solar power. I'm a little disappointed that you didn't have anything to say about a very important environmental aspect of photovoltaic cells, that is the energy payback period.

Solar panels require quite a lot energy to manufacture as the wafers of silicon have to be heated to a very high temperature as part of the "diffusion" process. So solar panels are not environmentally friendly until they have given back all that energy that went into manufacturing them! Actual payback period figures of 8-10 years seem to be generally accepted.

Solar panel manufacturers don't seem to want this aspect to be widely known but it puts a whole new slant on the solar energy debate. I presume that the 8-10 year payback period is based on full usage, so having a solar panel to just keep your boat battery topped up would not be "green" at all because you would probably never

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Ray Chapman,
via email.

Comment: to a large extent, the long payback period is reflected in the high price of solar panels. In other words, if solar panels were much cheaper to make, they would have a shorter payback period, both in financial and environmental terms.

Web link for Historical Radio Society

In the April 2002 issue of SILICON CHIP, Ray Creighton supplied you with the URL for the Historical Radio Society of Australia Inc. Unfortunately, he supplied the old address; The current address is **www.hrsa.asn.au**

Warwick Woods, President,
Historical Radio Society of Australia Inc.

Distributed power generation has merit

While I agree with your economic analysis on home installation of solar cells within the city, the basic idea of generating power on a distributed basis has real merit as it potentially reduces infrastructure expense.

Also the widespread use of local power generation might help reduce urban heating. Maybe business should be encouraged to install systems. Or maybe just shopping malls to reduce lighting costs, as their usage is fairly well in sync with daylight hours.

Paul Maynard,
via email.

Comment: distributed power generation makes a lot of sense. However business will not install any of these systems unless the payback period is realistic; five years or less.

Limitations of negative feedback

Keith Anderson (Mailbag, March 2002 issue) went to some length to extol the virtues of large amounts of negative feedback as employed in audio power amplifiers. I feel that some of his comments are misleading if taken at face value, however. Keith cites P. J. Baxandall, then follows this with some paraphrasing, leading to the conclusion that "a little bit of feedback makes things worse, not better."

He then tells us that "It is really dumb to do gross, brutal things like using class-A to reduce feedback", and that "it is necessary but difficult to use lots of it".

For Keith to discard such inherently linear systems such as Linsley Hood's 10-15W class-A design (Wireless World, April 1969) with these platitudes seems to me in itself "really dumb". Numerous authors (Baxandall, Bailey, Blomley, Hood and others) have gone to great lengths over the years to explain just exactly why negative feedback is not the panacea that Keith seems to imagine.

Class-B amplifiers have the operating point of each output device set at the lower extreme of its transfer characteristic. Most commercial designs still use bipolar (quasi) complementary symmetry output stages, and in these the mutual conductance varies wildly as an audio signal drives each output half (upper and lower) in and out of conduction. In other words, the open-loop gain varies significantly near the crossover point.

This is precisely why negative feedback is less than completely effective with such designs. At the crossover point, the open-loop gain falls and so does the amount (and the effectiveness) of the overall negative feedback.

To compound the problem further, most people only run their amplifiers at output levels of around a watt or less for general listening. This results in their audio signals being very close to this highly non-linear crossover point for most of the time and the resulting distortion level will be much higher than the manufacturer's quoted figure for (near) full output.

Such "bumpy and localised" nonlinearities also produce quite high-order harmonics, (9th, 11th and higher) and as such, are far more apparent to the human ear.

When the distortion is predominantly low-order harmonic, such as that produced by (eg) class-A designs, the same amount of distortion which causes audible "edginess" in class-B designs no longer sounds like distortion at all. Rather, it tends to make instruments and voices sound slightly "different" tonally, since the ear now has a much harder job picking the generated harmonics as separate, distinct signals. Class-A operation happens to be a very effective solution to these problems. Inefficient, maybe. But "really dumb, gross and brutal", as Keith suggests? Most certainly not!

Tony Sanderson, VK3AML,
Surrey Hills, Vic.

Wind power compares to solar

I thought the article on Solar Power in the March 2002 issue of SILICON CHIP by Ross Tester very well balanced and an accurate assessment of the situation. Yes, the "greenhouse effect" is far from proven. We should stop talking about "greenhouse gases" and refer to CO_2 or whatever gas is of interest, by name. Of course, if we are to conserve fossil fuel, we should be concerned about CO_2 emissions.

Ross did not mention small wind generators for use next to a home. We live on a windy hill and the notion of capturing some of that wind energy is appealing. A rule of thumb says the average wind speed needs to be about 6m/s to make a wind generator worthwhile. I have done calculations for a small wind generator which just feeds a heater and nothing else; the simplest possible system.

Assuming the 6m/s average applies for the whole year, thus assuming heating is needed all year, which it isn't, the payback time on the purchase of the generator, compared with heating by furnace oil and no subsidy, is of the same order as Ross's figures.

John Waller,
Connecticut, USA.

Solar power is a worthwhile investment

I read with some annoyance the article on "Solar Power for All: Does it Add up?". I was particularly concerned by the section entitled "Payback period".

Think of it as an investment and tell me this doesn't make sense: Let's assume the person does have $11,000 to invest. If your return on investment is $800 per annum that's 7.2% tax free! Because you are not selling the electricity, just subtracting it from what you buy in the first place, the government has not worked out how to tax us on the earnings.

Investing $11,000 in a term deposit

at 3.5% returns $385 per annum. If you are in the top tax bracket, take away 47% tax from that and you end up with $204; net return is 1.8% after tax. I give you one guess where I would put my money!

And let's face it, if you move house unbolt the system and take it with you because it is not going to add $11,000 of value to the house.

Alan Barrow,
Aspendale, Vic.

Comment: comparing "Plug'n'Power" to bank interest does make it seem more favourable except that you can always go to the bank and get your $11000 back. But we take your point: that a 7.2% notional return is actually equivalent to almost 15% before tax, when the top tax rate and Medicare levy is taken into account. The only problem is, how does a $20,000 solar system save $800 in a year? On our figures, the best saving you could expect would be less than $200 per year, not per quarter.

Solar power has a cost disadvantage

Ross's article about the solar power will put the cat amongst the solar panels! Seems it will be awhile yet before the price of solar comes down enough and the price of hydrocarbons goes up enough for there to be a direct economical benefit.

People will no doubt argue that Ross hasn't taken environmental costs/savings into account but neither will many people take it into account when they are deciding to make a purchase. The "Better ways to save greenhouse gases" (and costs) was very good!

G. Nolan,
via email.

Interest cost should be taken into account

I read Ross Tester's article entitled "Solar Power for All: Does it Add Up?" in March 2002 with interest.

Unfortunately, his financial analysis is nowhere near the standard of his technical analysis. He makes the common mistake of comparing the capital cost of one setup (solar power) with the current or running cost of another setup (paying electricity bills). This is like comparing apples with lemons! Talk of a payback period is irrelevant – especially if it ignores inflation and interest rates.

Ross states that "If your current electricity bill is, say, $200 per quarter then $11,000 is equivalent to 55 quarters". This is invalid because that $11,000 investment results in an asset being acquired. What he should be comparing is the cost of servicing the $11,000 investment against electricity bills.

Current mortgage rates are about 1.5% to 2% per quarter. So the cost of setting up $11,000 worth of solar equipment comes to around $165 to $220 per quarter – roughly equivalent to the cost of buying electricity from the authorities.

Therefore, you have two ways of paying for your electricity: you can give it to the electricity generating authorities and help to burn more coal or you can give it to your banker and enjoy "green" electricity. Another way of looking at this is that if you have $11,000 to invest then one option is to invest in solar power. The $200 or so that you save in electricity bills each quarter represents tax-free interest on your investment.

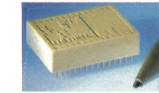
Of course this is an idealised assessment in that it does not take into account depreciation, maintenance costs or inflation. When we analyse Pacific Solar's "Members Pack" using Ross's figures then we get a significant difference in costs. The $6000 investment has a life of 25 years (this takes account of depreciation). If we assume that the real interest rate (the difference between the mortgage rate and inflation) is 5%, then the annual cost of the investment is $425 – significantly more than the $64 that the 640kWh would cost each year if you got it from the authorities.

Of course, maintenance needs to be added on top of this. No figures are given for maintenance of a solar power system but I guess that a preventative maintenance program would cost $20 to $50 per year.

Incidentally, I notice that Ross suggests that gas or solar hot water systems might be a better way to save greenhouse gases. It might be better to crunch a few numbers before you make this conclusion Ross!

G. Schoenmakers,
via email.

The Tiger comes to Australia



The BASIC, Tiny and Economy Tigers are sold in Australia by JED, with W98/NT software and local single board systems.

Tigers are modules running true compiled multi-tasking BASIC in a 16/32 bit core, with typically 512K bytes of FLASH (program and data) memory and 32/128/512 K bytes of RAM. The **Tiny Tiger** has four, 10 bit analog ins, lots of digital I/O, two UARTs, SPI, I²C, 1-wire, RTC and has low cost W98/NT compile, debug and download software.

JED makes four Australian boards with up to 64 screw-terminal I/O, more UARTs & LCD/keyboard support. See JED's www site for data.

TIG505 Single Board Computer

The TIG505 is an Australian SBC using the TCN1/4 or TCN4/4 Tiger processor with 512K FLASH and 128/512K RAM. It has 50 I/O lines, 2 RS232/485 ports, SPI, RTC, LCD, 4 ADC, 4 (opt.) DAC, and DataFLASH memory expansion. Various Xilinx FPGAs can add 3x 32bit quad shaft encoder, X10 or counter/timer functions. See www site for data.

$330 PC-PROM Programmer

This programmer plugs into a PC printer port and reads, writes and edits any 28 or 32-pin PROM. Comes with plug-pack, cable and software.

Also available is a multi-PROM UV eraser with timer, and a 32/32 PLCC converter.

JED Microprocessors Pty Ltd
173 Boronia Rd, Boronia, Victoria, 3155
Ph. 03 9762 3588, Fax 03 9762 5499
www.jedmicro.com.au

HELIOS

On August 13th 2001 over Hawaii, the AeroVironment Helios Prototype powered flying wing reached a height of 96,863 feet, thereby setting a new altitude record for winged aircraft.

At first glance, this is a wonderful achievement. But that is only the beginning of an even more stunning set of achievements planned for this amazing aircraft, including its first commercial test flights this month.

So, what is the Helios Prototype and just what is the story of this most remarkable and unique aircraft?

The Helios Prototype is a remotely-piloted solar-powered flying wing developed to demonstrate the capability of achieving two significant milestones for NASA's Environmental Research Aircraft and Sensor Technology (ERAST) project.

Firstly, reaching and sustaining flight at an altitude near 100,000 feet and secondly, flying non-stop for at least 24 hours including at least 14 hours above 50,000 feet.

In 2001, Helios achieved the first of these goals by reaching an unofficial world-record altitude for a non-rocket powered aircraft of 96,863 feet and sustaining flight above 96,000 feet for more than 40 minutes during a test flight near Hawaii.

The Helios Prototype is an enlarged version of the Centurion flying wing, flown at Dryden, California in late 1998 to verify the handling qualities and performance of a lightweight all-wing aircraft of more than 60-metre wingspan.

It was renamed the Helios Prototype to clearly identify it as a forerunner of the eventual Helios production aircraft, which will be designed to fly continuously for up to six months at a time on scientific and commercial missions.

Developed by AeroVironment Inc, of Monrovia, California, the Helios Prototype has what is probably the most interesting pedigree in aviation history. In 1959 the British industrialist Henry Kremer announced a competition with a prize of $95,000 for the first man-powered aircraft to successfully demonstrate sustained, manoeuvrable human-powered flight.

Dr Paul MacCready and Dr Peter Lissamen designed the "Gossamer Condor", constructed of thin aluminium tubes and Mylar film, supported with stainless steel wire. On August 23, 1977, championship bicyclist and hang-glider enthusiast Bryan Allen flew the Condor for 7 minutes, 2.7 seconds, over a closed figure-8 course to win the coveted $95,000 Kremer Prize.

Gossamer Albatross

In 1979, MacCready's Gossamer Albatross, with the same 32kg weight and 29-metre wing span as the Condor,

the solar powered plane

by Bob Young

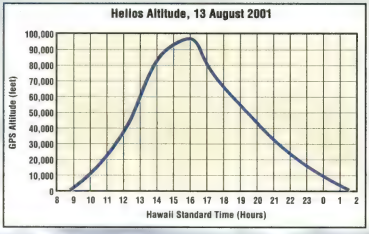


Fig.1: record flight altitude/versus time chart.

crossed the English Channel in turbulent winds in three hours. Cyclist Bryan Allen, who pedaled the Gossamer Condor, also provided the human power for the Albatross.

For MacCready and the other manpower enthusiasts, it was a tough battle. To illustrate just how tough, consider the following. A hang-glider requires 1.5hp to sustain level flight whereas a man can only generate about 0.3-0.5hp. MacCready believed that a big, efficient, super-light wing was the answer and set about to prove it. While the knockers stood around with their hands in their pockets, betting it could not be done, MacCready simply went about his business putting his muscle where his mouth is, quietly betting that it could be done. MacCready won! And he won in more ways than one.

As a result of the public exposure from the Gossamer Condor and Gossamer Albatross, Dr MacCready's company AeroVironment, dedicated to environmentally friendly technologies, embarked on a remarkable series of projects, some of which are shown in Fig.2.

While seeking ways of storing energy on board a human-powered aircraft – by means of a battery charged by the pilot's pedaling – MacCready's team gained insights into making efficient use of very limited battery power. Back on terra firma, he has made his mark as well. He guided the team that developed the GM Sunraycer, a solar-powered car that won a 3000km race across Australia. MacCready's team, with GM support and help, then developed the Impact demonstrator electric vehicle, which in 1991 stimulated California's zero-emissions mandate. The Impact became the currently available EV1.

MacCready traces his company's success in this field in no small part to the experience his team gained while running after his fragile flying machines. This is a stunning story about a remarkable man and it all began because a friend defaulted on a $100,000 loan that Paul MacCready had guaranteed and he needed that $95,000 Kremer prize to pay it back.

Following Solar Challenger and making use of the expertise gained on human-powered aircraft, MacCready's team developed the unmanned and solar-powered Pathfinder, the first of the high-flying solar UAVs. In July 1997, Pathfinder set a new altitude record

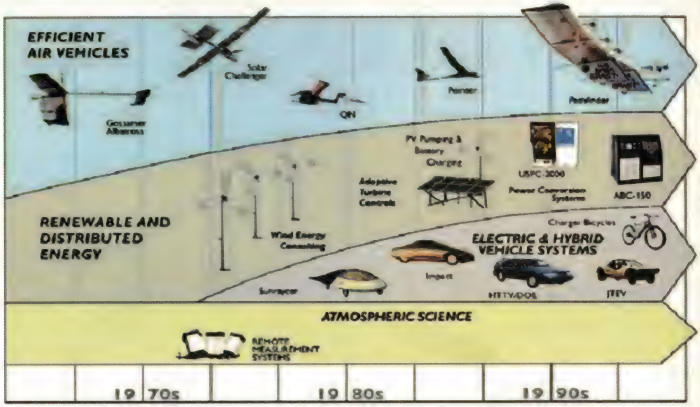


Fig.2: Paul MacCready's Aeronvironment Inc is also responsible for many other environmentally-based projects and is not confined to aircraft by any means. They're into electric vehicles and renewable energy – and even power-assisted pushbikes! Our apologies for the quality of this graphic . . .

for propeller-driven planes by reaching 21.8 kilometres (71,500 feet). Pathfinder-Plus followed and pushed the propeller-driven altitude record to 82,000 feet.

Pathfinder was followed by the 62-metre span Centurion which was flown in 1998. The Centurion's wingspan was then extended to 75 metres and the aircraft was renamed the Helios Prototype. The Helios Prototype is only one of many remotely piloted aircraft that have been involved in NASA's ERAST project (see Fig.3).

The Helios Prototype was designed as a solar-powered propeller-driven aircraft, although the first series of test and evaluation flights in the summer of 1999 used batteries to power its 14 electric motors. High efficiency solar panels were installed in 2000 for further development flights, which were flown during the summer of 2001 over the Pacific Ocean near Hawaii.

At the limits

Flight at the absolute ceiling for any aircraft is a precarious business. As the air thins, propellers lose efficiency, thrust drops off and the wings struggle to maintain the required lift. Approaching absolute ceiling, the rate of climb falls away and once it falls below 100 feet/minute the aircraft has reached what the military people define as the "service ceiling".

At "absolute ceiling", the rate of climb has fallen to zero and the maximum speed and the stalling speed have finally converged, so there is only one speed at which the aircraft can fly. At this point, nasty things can happen to an inattentive pilot.

An interesting sidelight here is that flight at 100,000 feet roughly approximates atmospheric conditions on Mars, which means the Helios Prototype is providing valuable data for the proposed Martian Aircraft.

NASA's ERAST project is aimed at the development of aeronautical technologies that are expected to produce a new generation of remotely piloted or autonomous aircraft for a variety of upper-atmospheric science missions. The ERAST project aims at revolutionising the way in which aircraft are designed and built.

Flying at slow speeds for long periods of time at altitudes of up to 100,000 feet, post-ERAST vehicles may be used to gather, identify and monitor environmental data. Other applications may include assessing global climate changes, studying Earth resources, assisting in disaster recovery situations or serving as telecommunications platforms, all at a fraction of the cost of placing satellites into space.

Here one wonders at the practical problems to be encountered with sustained operations at altitudes in excess of 60,000 feet. Ultraviolet radiation strips plastic of its plasticiser and the film becomes brittle and easy to snap. Add to this the extreme cold at those altitudes, exacerbating the brittleness, and suddenly the job of keeping the airframe intact for six months becomes an awesome task. Still, does anyone doubt that it will be done?

A parallel effort to developing the aircraft is the development of the lightweight, micro-miniaturised sensors that will be used to carry out the environmental research and Earth monitoring.

Also contributing to the ERAST program in the areas of propulsion, energy storage systems, structures, systems analysis and sensor technology are NASA's Glenn, Langley and Ames Research Centers. NASA is also working closely with the Federal Aviation Administration to develop "de-

Coming or going? Actually, it's going: Helios Prototype taking off from the US Pacific Missile Range Facility, Kauai, Hawaii, at the start of its record-breaking flight: 8.48AM, August 18 2001. The first commercial test flights of Helios (with communications technology and remote imaging payloads) are actually planned for this month (June 2002).

tect, see and avoid" systems which are over-the-horizon command and control technologies and operational plans so that remotely-controlled aircraft can be safely flown in national airspace. All of this is part of the rapidly developing unmanned aerial vehicle movement that long-term readers of SILICON CHIP have been kept well informed about over the past 10 years.

As a result of the successful Helios Prototype flights, Aerovironment have established a subsidiary company, SkyTower Inc, to commercialise Helios. Here Helios is envisioned as merely one component in a complex communications network known as SkyTower. As part of the SkyTower network, Helios is to be used as a virtual geostationary satellite, circling for periods of up to six months.

According to AeroVironment, Helios, acting as a geostationary satellite but without the time delay (equivalent to an 18km high tower), has many advantages:

- Low overall system cost.
- Concentrates capacity over populated areas and provides high look angles, resulting in improved coverage compared to satellite and terrestrial systems. For example, a single aeroplane can cover a service area of approximately 64km in diameter with a look angle from 30-90°. d
- Can increase bandwidth capacity.
- Due to the lower elevation of Helios compared with space satellites, less power is required for transmitting

Fig.3: other aircraft associated with NASA's ERAST project. In the main pic are the Proteus (Sealed Composites), the Perseus (Aurora), the Centurion (AeroVironment) and the Altus II (General Atomics). Inset above are the Pathfinder Plus (AeroVironment) and Altair (General Atomics).

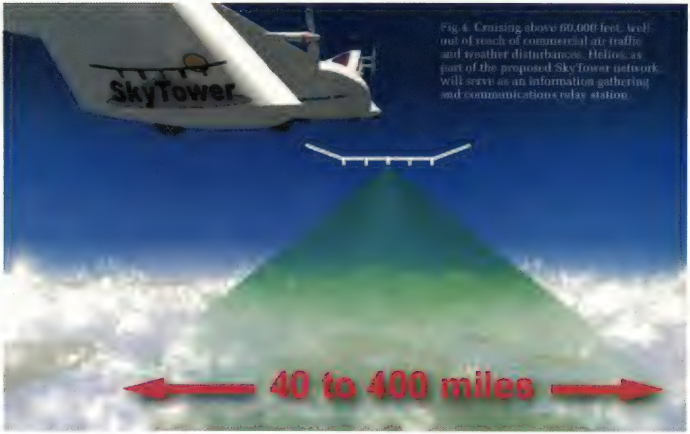


Fig.4. Cruising above 60,000 feet, well out of reach of commercial air traffic and weather disturbances, Helios, as part of the proposed SkyTower network, will serve as an information gathering and communications relay station.

and receiving, smaller/lower cost communications equipment can be used and/or network performance can be improved.

- Rapidly deployable to provide immediate target coverage and easily relocated, maintained and upgraded.

Aircraft Description

The Helios Prototype is an ultra-lightweight flying wing aircraft with a wingspan of 75 metres. This is longer than the wingspans of the US Air Force C-5 military transport (68m) or the Boeing 747 jetliner (65m). The electrically powered Helios is constructed mostly of composite materials such as carbon fibre, graphite epoxy, Kevlar, styrofoam and a thin, transparent plastic skin.

There are 14 1.5kW electric motors on the aircraft. During the dark descent on the record-breaking flight, these became generators to power the aircraft electrics.

The main tubular wing spar is made of carbon fibre. The spar is thicker on the top and bottom to absorb the constant bending motions that occur during flight and is also wrapped with Nomex and Kevlar for additional strength. The wing ribs are also made of epoxy and carbon fibre. Shaped styrofoam is used for the wing's leading edge and a durable clear plastic film covers the entire wing.

The Helios Prototype uses the same wing plan-form as its predecessors, Pathfinder and Centurion. With a wingspan of 75.3m and a chord of 2.43m, (distance from leading to trailing edge) the Helios Prototype has an aspect ratio of almost 31:1. The wing thickness is the same from tip to tip, 292mm or 12% of the chord, and it has no taper or sweep. The outer panels have a built-in 10° dihedral (upsweep) to give the aircraft more lateral (roll) stability. A slight upward twist of the tips at the trailing edge (washout) helps prevent wingtip stalls during the slow landings and turns.

The wing area is 183 square metres, giving the aircraft a maximum wing loading of 4kg/m^2 when flying at a gross weight of 750kg. This is an extremely low wing loading when one considers that the typical R/C model flies with a wing loading of 7-9kg per square metre and full size aircraft may push the wing loading up into the hundreds of kilograms per square metre. However, this low wing loading is absolutely essential in the ultra-thin air at 100,000 feet.

The flying wing aircraft is assembled in six sections, each 12.5 metres long. An underwing pod is attached at each panel joint to carry the landing gear, the battery power system, flight control computers and data instrumentation. The five aerodynamically-shaped pods are constructed mostly of the same materials as the wing itself, with the

exception of the transparent wing covering.

The fixed landing gear is contained in the underwing pods and consists of rugged mountain bike wheels on the rear and smaller scooter wheels on the front; the lineage from Gossamer Condor is unmistakable.

Power is provided by 14 brushless DC electric motors mounted across the wing's entire span. The motors are each rated at 1.5kW and drive lightweight two-blade, wide-blade propellers two metres in diameter. The propellers are made from advanced composite materials and feature a laminar-flow design for maximum efficiency at high altitudes.

For the first flight tests carried out at Dryden in 1999, the Helios Prototype was powered by lithium battery packs carried in the underwing pods. Eventually, more than 62,000 solar cells were installed on the entire upper surface of the wing during the year 2000.

The final design stage for long-duration missions calls for the solar cells to not only power the electric motors but also to charge an on-board fuel-cell based energy storage system. This system now in development will power the motors and avionics through the night.

The cruising speed of Helios ranges from 19-27mph at sea level to 170mph ground speed at extreme altitudes, with takeoff and landing speeds not quoted. However these are presumably around the 10-12mph mark. Here one wonders about the practical problems encountered when operating an aircraft with such low airspeeds.

Ground speed can be very quickly eroded and assume negative values (in other words, flying backwards relative to the ground) in any sort of headwind. Some of the small

Fitting just some of those 62,120 high-efficiency bi-facial PVCs (solar cells). They account for about $US10 million of the Helios Prototype's $US15million price tag.

Helios Prototype Specifications

Wingspan:	75.3 metres.
Length:	3.6 metres.
Wing Chord:	2.4 metres.
Wing Thickness:	292mm (12% of chord).
Wing area:	185 square metres.
Aspect Ratio:	30.9:1
Empty Weight:	600kg.
Gross Weight:	Up to 928kg; varies depending on power availability and mission profile.
Payload:	Up to 330kg, including ballast, instrumentation, experiments and a supplemental electrical energy system, when developed.
Electrical power:	62120 bi-facial solar cells covering upper wing surfaces. Cells are silicon-based and are about 19% efficient in converting solar energy into electrical power. Lithium battery backup to allow limited operation after dark.
Propulsion:	14 brushless DC electric motors, each rated at 2 HP (1.5kW), driving two-blade, wide-chord, 2-metre diameter laminar-flow propellers designed for high altitude.
Airspeed:	19-27 mph cruise at low altitudes, up to 170 mph ground speed at extreme altitude.
Altitude:	Designed to operate at up to 100,000 feet, typical endurance mission at 50,000 to 70,000 feet.
Endurance:	With solar power, limited to daylight hours plus up to five hours of flight after dark on storage batteries. When equipped with a supplemental electrical energy system for night-time flight, from days to several months.
Primary Materials:	Carbon fibre composite structure, Kevlar, styrofoam leading edge, transparent plastic film wing covering.

electric-powered UAVs used in operation Desert Storm suffered badly due to their low speed envelope and proved unusable in windy conditions.

Yaw (turning) control is effected by applying differential power on the motors – speeding up the motors on one outer wing panel while slowing down motors on the corresponding inner panel.

Pitch control is currently via 72 small trailing-edge elevators operated by 72 small servos. Spanning the entire wing, they are operated by the aircraft's fight control computer. There is no mention of roll control in any of the literature provided.

An alternative method of pitch control is currently under investigation using the dihedral and inflight wing flex to provide some differential in height between the inboard and outboard motors. As the outboard motors are higher than the inboard motors, increasing the power on the outboard and decreasing the power on the inboard will result in a nose-down pitch angle. Conversely, increasing the inboard power and decreasing outboard power will result in pitch up or climb.

If successful, using this system will allow the removal of about 15kg of servos and control equipment, a valuable saving in such a lightweight structure. Also, the wing space now being used by the elevators could also be covered with solar arrays for additional power.

The ultimate objective of the Helios design is to carry a payload of scientific instruments or telecommunications relay equipment averaging about 90kg to high altitudes for missions lasting from several days to several months. Empty, the Helios Prototype weighs in at only 600kg. Payloads vary depending upon the type of mission to be flown.

During the 1999 development flights, the aircraft carried payloads of up to 280kg – a combination of ballast and instrumentation, with the amount on each flight determined by the flight objectives. During the 2001 flights, the Helios Prototype flew at a weight of about 725kg, including its flight test instrumentation.

The Helios Prototype follows the normal UAV control pattern, being controlled remotely by a pilot on the ground, either from a mobile control van or a fixed ground station equipped with a full flight control station and consoles for systems monitoring.

As required on all remotely piloted aircraft flown in military restricted airspace, a flight termination system is provided. This includes a parachute system deployed on command plus a homing beacon to aid in the aircraft's location.

In case of loss of control or other contingency, this system is designed to bring the aircraft down within the restricted airspace area to avoid any potential damage or injuries to personnel on the ground.

Round-the-clock operation

A supplemental electrical energy source will be required to provide power to operate the motors, avionics and experiment payloads when flying the solar-electric Helios Prototype at night or when no sunlight is available. Two versions are currently under development, one regenerative, one non-regenerative.

AeroVironment is developing an intermediate fuel cell-based system without regenerative capability that will enable the Helios Prototype to achieve flight over a full diurnal cycle (ie, day and night) by the NASA milestone deadline of September, 2003. Fuel cells using proton-exchange membranes will combine hydrogen carried in pressurised tanks with oxygen from the atmosphere, producing electricity to power the aircraft at night. Although the goal is at least 24 hours, project officials hope to demonstrate that Helios can stay aloft for several days.

The more ambitious regenerative system, based on hydrogen-oxygen fuel cell and electrolyser concepts, is a long-term goal. Briefly, the system would employ water as the primary component, with an electrolyser using excess electricity to break water into hydrogen and oxygen during the daytime, with the gases released being stored under pressure. At night, the process would be reversed, with a fuel cell recombining the two gases into water, with electricity produced as a byproduct.

Depending upon funding availability and the overcoming of a variety of technical problems, development of the fully regenerative system would allow for a long-endurance demonstration mission of at least four days, some time in the future. Perhaps this eventually will allow Helios to fly for weeks or months on end.

However, even the prototype Helios can achieve extended flight times by judicious use of the on-board storage batteries and solar cell banks. Taking off early in the morning uses all the daylight hours to provide the propulsion for climb to altitude. Descent and return home requires significantly less power (avionics and control only) and can then be carried out in darkness using the internal batteries, augmented by the regenerative power produced in the now freewheeling motors.

Referring to the record breaking altitude/versus time chart in Fig.1, we see take off from the US Navy's Pacific Missile Range Facility on the Hawaiian island of Kauai at 8:48 AM on August 13th and landing some 17 hours later at approximately 1:43 AM the following morning, August 14, several hours into darkness.

So there you have it, truly a most interesting story. Perhaps the last word belongs to Dr MacCready's company citing some of the potential advantages for this impressive aeroplane:

* *Long flight duration – of up to 6 months or more.*
* *Minimal maintenance costs due to few moving parts (each motor has only one moving part).*
* *High levels of redundancy (the aircraft could lose several motors and still maintain station and land safely – most failure modes do not require immediate response by the ground station operator).*
* *Highly autonomous controls which enables one ground operator to control multiple aircraft.*
* *Use of solar energy to minimise fuel costs.*
* *Tight turn radius which makes the platform appear geostationary from the ground equipment perspective (ie, enables the use of stationary user antennas) and enables multiple aircraft to serve the same area using the same frequency spectrum.*
* *Flexible flight facility requirements (the aircraft can even take off from a dirt field and in less distance than the length of its wingspan).* **SC**

Acknowledgments: Thanks to Alan Brown of NASA and the people at AeroVironment.

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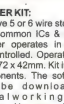
Mini stepper motor: (M555) $7 each
Package (Kit plus stepper motor): (K179M).$29



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(NEW) DOT MATRIX LED DISPLAY: 8 x 5 red matrix displays (part # TOM-2258) each measuring 32 x 50mm: (DL11) $5 each

655nM VISIBLE LASER DIODE MODULE: Consists of a visible laser diode, diode housing, driver circuit, and collimation lens all factory assembled in one small module. These are suitable for lightshows, industrial and levelling applications. The focus can be adjusted. Overall dimensions of case is 12mm diameter by 37mm long.
3mW 655nm (RED)3 to 4V @ 55mA(LMA3) $18
6mW 655nm (RED) 3 to 4V @ 60mA(LMA6) $36
10mW 655nm (RED) 3 to 4V @ 65mA(LMA10) $90
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GEARED STEPPER MOTOR:
AIRPAX Brand, model # C35M048A03-X, 12V DC Operation, 155ohm coil resistance, 4 wire. 1350:1 gear reduction. 7.5degree step angle. These small geared stepper motors would be ideal for telescope tracking etc. Measures 62mm long, 54mm wide & 26mm high. D shaped shaft protrudes 10mm and the diameter is 3.5mm: (MS54) $16 - NOW AVAILABLE

(NEW) ZERO-CROSSING SOLID STATE RELAY (SC842910):
Maximum switching current is 25A, Maximum Switching voltage is 12-280V AC and Control Voltage 90-240V AC.(RL7A) $25

Zero-Crossing Solid State Relay (SC844910): Maximum switching current is 40A, Maximum Switching voltage is 12-280V AC and Control Voltage 90-240V AC.(RL7B) $33

Zero-Crossing Solid State Relay (SC868110): Maximum switching current is 95A, Maximum Switching voltage is 24-520V AC and Control Voltage 5-30V DC.(RL7C) $89

(NEW) Zero-Crossing Solid State Relay (SC869110): Maximum switching current is 125A, Maximum Switching voltage is 24-520V AC and Control Voltage 5-30V DC. Check the following website for more information: http://www.celduc-relais.com/uk/biphase.asp> (RL7D) $100

12V / 7AH SEALED LEAD ACID BATTERY: We are overstocked with these fresh stock batteries so now is the time to pick up a real bargain, 2.6kg, 150 x 65 x 92mm: (PB6) $25

SONY® UNIVERSAL CAMCORDER BATTERY & CHARGER:
Brand new in original packing less than 1 year old. 7.2V / 1500mAH (10.8Wh) lithium-ion. As commonly used with SONY® digital cameras, camcorders and some other brand products. This pack is exactly the same as our SONY® NP-F550 digital camera battery. Measures 70 x 38 x 18mm. Made by Optex (USA). Optex part number Li55-L. Charger has unusual plug that is easy to adapt. Requires 9V / 1A plugpack (not supplied). These batteries will not work with some later model SONY® cameras. Some cameras will only accept genuine SONY® batteries: (ZA0278) $26 - Back Again at a Special Price

Series IV 4 CHANNEL UHF RECEIVER KIT:
Combined with our Series IV Code Hopping Transmitter (K164), this receiver kit can control four output relays in either toggling or momentary operation. Uses a pre-built and pre-aligned 433MHz UHF (crystal locked) code hopping receiver module. This receiver module can learn up to 15 transmitters. Output relays have high current contact ratings. 12V DC operation. Receiver kit includes PCB and all on-board components. (K180) $54 Series IV 4 CHANNEL UHF TRANSMITTER KIT:
Transmitter has 4 channels and operates from 12V lighter battery (supplied). Uses a pre-built and pre-aligned 433MHz UHF code hopping transmitter module. Transmitter kit includes transmitter module, battery clips, 12V battery and key-fob case: (TX4) $25

(NEW) RELAY & TRANSFORMER PANEL:
Ideal for automation and control projects. These are brand new and were built for an industrial application that didn't go ahead. Includes five high quality 24V relays with contacts rated at 30A and a 240V / 24V (20VA) transformer all mounted on a metal plate. The Hasco brand relays (model #HATF903ASAC24) will operate well at 9V and drop-out at 4V: (ZB0212) $15

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2.4 Ghz VIDEO TRANSMITTER ANTENNA

We built one of these antennas and fitted it to our 2.4Ghz video receiver only (not the transmitter) and received a good clear signal at 500M , it may receive over a greater distance but 500M was as far as we tested. This antenna is made from a popular potato chip container & some nuts and washers etc. from a local hardware. the design plans are published on our web-site and is free to download. (we do not recommend fitting it to the transmitter as this may contravene the law, check with your local authority) Ideal for use with the following kit.

MINI 2.4Ghz 10 mW VIDEO TRANSMITTER (Max. legal power)
15 X 15 X 5mm (Main body). This is the smallest 2.4 Ghz 10Mw transmitter we have seen. Requires 5Vdc. Will Transmit up to 100 Mtr. with a 30mm wire as an antenna. Module "A" plus module "C" $169

10mW 2.4Ghz STEREO AUDIO VIDEO TRANSMITTER AND RECEIVER MODULES Will Transmit up to 100 Mtr. with a 30mm wire as an antenna.:$90

STEREO AUDIO VIDEO TRANSMITTER / RECEIVER KIT.
This kit contains modules as per C & D and includes PBCs and all on-board components. :$119

CAMERAS

MINI HIGH QUALITY LOW LIGHT CMOS PINHOLE CAMERA
20 X 25 X 19mm. $98

MINI HIGH QUALITY LOW LIGHT CMOS BUTTON HOLE CAMERA WITH AUDIO
30 X 30 X 30mm. :$82

MINI HIGH QUALITY LOW LIGHT CMOS BUTTON HOLE CAMERA WITH AUDIO and HOUSED IN A SECURITY DOME
Dia. 86mm X 60mm. $92

(NEW) ALCATEL ESWA HEATING CABLE:
Type TXKP/TXKPV - 0.70 OHM/M - (2893), part No.(099956) or (0.20 ohm/m) part NO. (099957) This extremely strong high quality cable is designed to be embedded into concrete. Can be used for many applications but is especially attractive to those who wish to lay into their concrete (when building) so that they can have localised heating. Constructed of three 1 mm wires at the centre and then wrapped with 4mm (diameter) of black silicon, with a plastic sheath. Total width is ~5 mm. Minimum purchase of 10 metres. $7 for 10M

Lock out the bad guys with a firewall

by Greg Swain

If you connect to the Internet, you need a firewall. Here's a quick rundown on three very effective firewalls: ZoneAlarm, Sygate Personal Firewall & Tiny Personal Firewall. They're all free for personal use so there's no excuse for not taking action to protect yourself.

CONNECTING A COMPUTER to the Internet without a firewall is like leaving a car unlocked with the keys in the ignition. Without a firewall, your PC can easily be hacked and sensitive data stolen. In addition, a cracker (or Internet vandal) could damage the operating system or use your machine to launch further attacks against other PCs connected to the Internet.

Users with broadband connections, such as cable modems and ADSL, make particularly juicy targets. There are a couple of reasons for this.

First, every computer connected to the Internet must have a unique IP (Internet Protocol) address and broadband users usually either have a fixed address or one that is assigned for very long periods of time (ie, a "leased" IP address). That makes it easy for a cracker to repeatedly return to the same computer and wreak further mischief.

Second, users of broadband connections are more likely to be connected to the Internet for very long periods, if not permanently. That, plus the high-speed nature of the connection, means that crackers are more likely to zero in on users with cable modems or ADSL.

By contrast, if you access the Internet via a dial-up connection, your PC receives a different IP address each time it makes a connection. This makes it more of a moving target and, of course, the connection is much slower so it's less attractive for launching denial of service attacks.

But that still doesn't make you safe – not by a long shot. Once you're connected, an unprotected computer can quickly be "spotted" by a cracker using a software tool called a "port scanner". This allows the cracker to automatically portscan vast blocks of IP addresses to find out what which services are "listening" for a connection. A PC has some 65,535 ports (basically data pathways) and if they are left open, an intruder can gain access.

Of course, some ports are reserved for specific functions. For example, a web server communicates via port 80, FTP via port 21, incoming email via port 110 and outgoing email via port 25.

So be warned – an unprotected com-

Don't Let The Firewall Nag You!

Once you've set up all the rules for your firewall, you don't want it continually nagging you each time it encounters an unknown data packet. The way around this is to turn off the alert notifications. Here's how:

(1) In ZoneAlarm, go to the Alerts panel and clear the box next to "Show the alert popup window".

(2) In Sygate Personal Firewall, click Tools, Options and check the box next to "Hide notification messages".

(3) In Tiny Personal Firewall, click the Advanced tab and clear the box next to "Ask for action when no rule is found".

If you later find that the firewall blocks something that it shouldn't you can quickly re-enable the alert messages, create the new rules then disable the messages again. The log files can also help you sort out any problems.

Finally, a tip – if your computer automatically dials out each time it is booted after a firewall has been installed, find and uncheck the "Check For New Version" or "Check For Update" (or similar) option buried in the firewall setup menus.

puter is wide open and that applies even if you use a dial-up connection, since you can be spotted in just a few minutes. And if you're on a network with file and printer sharing enabled and bound to the Internet adapter, you're really asking for trouble.

Protecting yourself

So how do you protect your PC from unwelcome visitors? The answer is to install a firewall. This can either be a hardware device that sits between your PC and the Internet or a dedicated piece of software.

The most basic software firewalls simply function as port blockers; ie, they close unused ports to prevent unauthorised access. This is the type of firewall that's now incorporated into Windows XP.

More sophisticated firewalls such as ZoneAlarm, Sygate Personal Firewall and Tiny Personal Firewall not only close unused ports but also filter and inspect the TCP/IP network packets as they pass across the firewall interface (this technique is called "Stateful Inspection"). Unwanted or unauthorised packets are then blocked and logged, according to a set of rules built into the firewall. This not only allows them to block attempted intrusions but also prevents certain applications such as Trojan horses and spyware from communicating with the Internet from your computer.

A "Trojan horse", by the way, is a program that's smuggled into your computer (either via email or when you download from the web) to perform various nefarious activities.

Most firewalls (including these three) can also selectively block other PCs on a local network from having access to your machine. That's a worthwhile feature if you want to keep certain people in an office network from prying on sensitive data.

Keeping Trojans at bay

A feature of all three firewalls is that they create what are known as "MD5 signatures". Initially, these firewalls have to "learn" which applications have Internet access. These applications typically include web browsers, FTP and email clients, plus other utilities (eg, Windows Update).

Each time a new application is granted Internet access, the firewall creates an MD5 signature (basically a 128-bit algorithm) for that application. This signature is then stored and compared with the signature generated each time the application attempts to bind to a particular port. If the signatures match, then access is permitted.

This technique effectively blocks Trojan horse applications on your computer from accessing the Internet, since it prevents application "spoofing" – ie, where a Trojan attempts to disguise itself as a valid application. If the Trojan does attempt access, its MD5 signature will be invalid and it will be blocked.

Don't Take Security For Granted

For the home user, the firewalls described here should make for a fairly secure system – provided they are properly set up. Just keep them up-to-date and keep an eye on the log files for any suspicious activity and you should be OK.

However, we don't offer any guarantees – the net is not a safe place. If security is vital, be sure to seek expert help in setting up a firewall. Don't just rely on the advice in this article.

A look at ZoneAlarm 2.6.362

ZONEALARM is easy to install and operate. It comes in two versions: (1) ZoneAlarm 2.6.362 (the latest version at the time of writing) which is freeware; and (2) ZoneAlarm Pro 3.0 which is a retail version costing about $US40. The Pro version adds a few extra features over the freeware version, including Internet ad blocking, cookie control, full compatibility with ICS (Internet Connection Sharing) and the ability to block some 36 different email worms (Mailsafe).

For personal use, the freeware version should be sufficient. You can download it from **www.zonelabs.com** or from any one of a number of other sites but make sure you get the latest version.

When you launch ZoneAlarm (it's configured by default to automatically load at startup), the program places a small icon in your system tray and this also indicates incoming and outgoing traffic. To configure the program, you simply decide what level of security you want for your local network and Internet zones. The choices are Low, Medium and High and are independently set by dragging the two sliders.

The window text explains what the settings mean. For a standalone computer, you will want to set the Internet zone to High but this will have to reduced to Medium (which presumably weakens security) if you use Internet Connection Sharing.

The "High" setting is generally preferable because it places the machine into stealth mode. This makes all ports not in use by an application appear invisible to the Internet. By contrast, the "Medium" setting blocks port access but still leaves them visible, so it's not as good from a security viewpoint. Either setting blocks all Internet access to Windows services and to file and printer shares, a very necessary security feature.

Fig.1: ZoneAlarm offers independent security settings for the local network and the Internet.

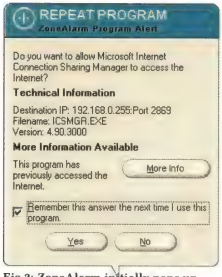

Fig.2: ZoneAlarm initially pops up frequent alerts until it "learns" which programs have access to the Internet.

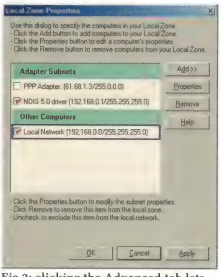

Fig.3: clicking the Advanced tab lets you add machines to your local zone but don't choose the PPP adapter.

Fig.4: the Programs tab shows which applications have been granted access to the Internet and to the Local Zone. You can also change the settings here, to grant or deny access.

Fig.5: placing the ZoneAlarm Desk Band on the taskbar gives you fast access to the various functions.

The Local zone can be set to "High" for a standalone computer but the "Medium" setting will be necessary if you want other local machines to have access to file and printer shares. Clicking the "Advanced" tab then takes you to the "Local Zone Properties" dialog. This is where you add "trusted" computers (eg, PCs on a local area network) to your Local Zone.

The "Adapter Subnets" are created and automatically maintained by ZoneAlarm. You only have to decide whether to check or uncheck the entries. For example, checking the Ethernet Adapter entry (under Adapter Subnets) enables access for all machines on the local network. Alternatively, you can leave this unchecked and simply specify the IP addresses for individual computers (or an IP address range) to add an additional entry to the "Other computers" section. Those machines not covered by an IP address (or address range) will then be blocked by the firewall.

Initially, ZoneAlarm displays frequent alert panels and you have to teach ZoneAlarm which applications are allowed access to the Internet. These applications typically include your web browser, email client (eg, Outlook Express) and any other Internet applications (eg, ICQ).

Basically, an alert panel pops up when ever an application requests access. You can choose to always block access for that program, allow access on a once-only basis or always allow access. By this means, ZoneAlarm quickly "learns" which programs can have access and which ones to block and the alerts all cease.

As well as blocking Trojans, this feature is also very effective when it comes to preventing "spyware" programs from contacting Internet-based servers without your permission.

Other features of ZoneAlarm include an Internet lock and "Mailsafe." Clicking on the lock immediately blocks all Internet activity, or you can set it to block all Internet traffic after a period of inactivity or when the screen saver activates. You can also give certain programs the right to bypass the lock (eg, if you want to check for email at regular intervals).

The MailSafe feature scans all incoming email attachments and quarantines any .vbs (ie, Visual Basic script) files by changing the extension to .zlx ("x" can be either a letter or a number). If you then try to open such attachments, ZoneAlarm pops up a dialog warning of the dangers of VB scripts and giving you an opportunity to back out.

Sygate Personal Firewall

LIKE ZONEALARM, Sygate Personal Firewall 5.0 makes your computer invisible to the Internet by closing all unused ports.

It also filters and inspects incoming and outgoing traffic using rule-based policies and can be configured to allow Internet access for trusted applications, plus selective access for computers on a local network.

Once again, there are two flavours – a freeware version for personal use and a fully-featured "Pro" version. Both versions now offer full support for Internet Connection Sharing, unlike the previous 4.2 version.

During installation, Sygate Personal Firewall automatically discovers the local area network and the ICS Manager and creates the rules necessary to allow Internet Connection Sharing. As with ZoneAlarm, it can be automatically configured to load at startup and (optionally) place an icon in the System Tray. This icon flashes red if an intrusion attempt is detected and you can double-click it to open the main console, before clicking the Logs button to review the security log.

Alternatively, right-clicking the tray

Testing Your Firewall

Once you have a firewall installed, you'll want to test its effectiveness. There are several web sites on the Internet that allow you to do just that. These commonly do port scans and test for other vulnerabilities, and some can even scan for the presence of known Trojans.

Of these, perhaps the best known sites are PC Flank at http://www.pcflank.com and Steve Gibson's ShieldsUp site http://www.grc.com. In addition, Sygate has a test site at http://scan/sygatetech.com and you are automatically connected to this when you click the Test button in Sygate Personal Firewall.

However, there are some situations in which the tests from these sites are rendered inaccurate. For example, if you use a proxy server, it's the proxy server (eg, at your ISP) that could end up being scanned – not your local machine with the firewall. That's because it's necessary for the test site to accurately determine your machine's IP address before running the tests and it's often the proxy's IP address that it recognises instead.

For example, the ShieldsUp site at www.grc.com has a tendency to recognise the proxy's IP but this is easily overcome by downloading a small utility called "IP Agent". Running this utility then sends the machine's correct IP address to the ShieldsUp test site, after which you can run the security checks.

The Sygate test site also has a habit of recognising the IP of the proxy server. In some cases, you may be able to get around the problem by disabling the proxy server settings in your web browser but that depends on your Internet Service Provider – disabling the proxy settings can sometimes prevent web access!

By contrast, in the tests we ran, the PC Flank site accurately determined the IP address of the local machine, despite the use of a proxy server. This site has several tests that you can run, including: Quick Test, Stealth Test, Browser Test (checks browser security), Trojans Test, Advanced Port Scanner and Exploits Test.

Testing a firewall that's on a client machine that accesses the Internet through a gateway (eg, via a PC with Internet Connection Sharing) also poses problems, since private IP addresses aren't recognised by the Internet. As before, the results of any web-based port scans and security checks will be misleading since it's either the gateway machine of the proxy server that will be scanned by the test site

icon gives you quick access to all the features of the firewall.

Security levels

There are three security levels – Block All, Normal and Allow All – and you can also click the "Block All" button on the toolbar to immediately block all Internet access. This is similar to the lock feature in ZoneAlarm.

The "Options" dialog box (found under the Tools menu) provides various configuration and local networking options, while the "Advanced Rules" dialog lets you create your own firewall rules based on IP numbers, port numbers and scheduling.

Fortunately, if you're a complete novice, you don't have to worry about any of this. Sygate Personal Firewall is all set to go immediately following installation. All you have to do is answer the alerts it pops up when you first start using it, to tell it which applications should be granted Internet access.

As with ZoneAlarm, Sygate Personal Firewall then uses your answers to create the access rules, so that the alerts cease after a short period of initial use.

Clicking the "Applications" button on the toolbar brings up the Applica-

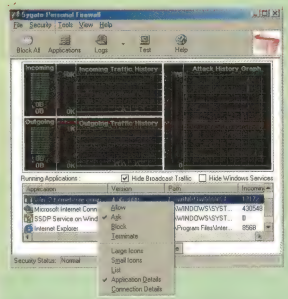

Fig.6: Sygate Personal Firewall 5.0 has an easy-to-use interface that displays network traffic and lists running applications. Right-clicking an application lets you change its access status.

Fig.7: you can quickly gain access to Sygate Personal Firewall's main functions by right-clicking its icon in the System Tray.

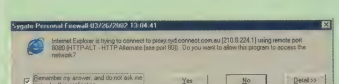

Fig.8: like ZoneAlarm, Sygate Personal Firewall "learns" which applications have Internet access.

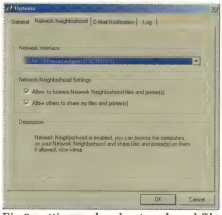

Fig.9: setting up local network and file and printer sharing rights is a "no-brainer" in Sygate Personal Firewall.

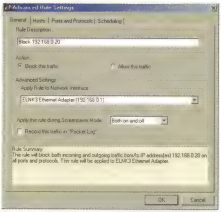

Fig.10: the Advanced Rule Settings let you specify access rights for certain IP addresses, ports and protocols.

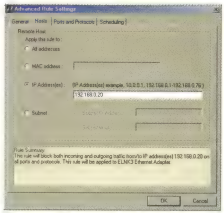

Fig.11: in this case, the firewall is blocking a computer on the local network with an IP of 192.168.0.20.

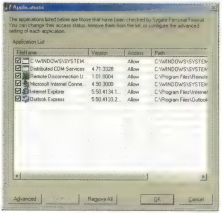

Fig.12: this dialog box lets you quickly change Internet access rights for various applications.

tions list. You can change each application's access status by right-clicking it and choosing either Allow, Ask or Block from the drop-down menu.

Tracing attacks

A neat feature of Sygate Personal Firewall is its ability to trace the path of an attempted intrusion. However, you can normally only trace the source of an attack back to the router used by the hacker to launch the attack, not the hacker's computer itself.

Finally, the Test button on the main console logs you onto Sygate's test site, so that the effectiveness of the firewall can be checked. This not only provides port scans and other security scans but can also scan for the presence of Trojans.

Note however, that Internet test sites do not always give accurate results if you are using a proxy server or are connected to the Internet via a gateway (eg, using ICS) – see the "Testing Your Firewall" panel for further details.

Finally, Sygate Personal Firewall features password protection. This is designed to prevent your security settings from being changed by other users of the machine. And like ZoneAlarm, it can be set to block all Internet traffic while the screen saver is active.

Tiny Personal Firewall

LAST BUT NOT LEAST, there's Tiny Personal Firewall. Let's call it TPF for short.

As with the previous two firewalls, it's best to fire up all your Internet applications when you first install TPF so that it can learn the ropes. TPF then creates filter rules based on your responses to the alerts it throws up (you can customise these rules if necessary).

TPF's administration utility is launched by double-clicking the icon in the System Tray and is, initially at least, disarmingly simple in appearance. The level of protection is set using the 3-position slider control. You can choose to cut off all network activity (top position), permit network activity according to the rules that have been set (centre position) or allow all network activity (bottom).

The medium security (centre) position is the default level and is necessary if you want Internet access but want to keep the firewall rules in place (the top maximum security setting blocks everything, including Internet access). TPF provides a few pre-defined filter rules and the user is prompted to set up a new filter rule (permit or deny) each time an unknown data packet is encountered.

Clicking the Advanced tab launches the Firewall Configuration menu and opens up a whole new world. This initially displays the Filter Rules dialog, which lists all the rules that have been created. You can then edit, add or delete rules, change the rule order and even set time frames for individual filter rules if necessary. However, you will need to have a reasonable understanding of TCP/IP and port addressing to do this if you intend to create the rules from scratch.

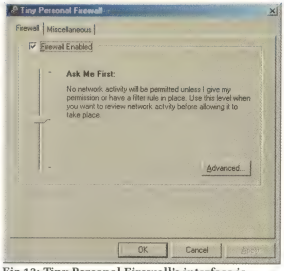

Fig.13: Tiny Personal Firewall's interface is disarmingly simple at first glance.

Alternatively, if you don't know how to create the rules, you can let the wizard do it for you each time you attempt to access a resource or browse to a network share from another machine. All you have to do is make sure that the box next to "Ask for action when no rule is found" is checked and follow the bouncing ball to create the rules from the alerts that pop up.

The other tabs on the Firewall Configuration control panel (Microsoft Networking, Miscellaneous & Application's MD5) let you set up local area networking options, trusted address groups and logging options. There's also an "Is running on Internet gateway" option that you can check (under Miscellaneous). This feature is apparently designed to make TPF work with Internet Connection Sharing but I couldn't make it work on the two ICS gateway machines I tested it on.

With TPF installed on a gateway machine, I was unable to browse the Internet from any of the client machines – even with the firewall disabled (or completely shut down for that matter). Full browsing rights were immediately restored when TPF was uninstalled, however.

But don't let this put you off TPF. If you don't plan to run this firewall with Internet Connection Sharing, it really doesn't matter.

Filtering the local network

One very nice feature about TPF is that it detects if there is a local area network as soon as the machine is rebooted after installation. The user is then prompted to permit or deny the network traffic. If it's permitted, then the LAN's all set to go without any further action from you.

By default, TPF sets up a "Trusted address Group" for your LAN and displays this under the Microsoft Networking tab. This means that if the machines on the LAN have 192.168.0.x IP addresses (where x is a number between 1 and 254 and is different for each machine), then TPF sets up a trusted address group of 192.268.0.0/255.255.255.0.

This rule simply allows all machines on the 192.168.0.x network to access shared resources on the machine with the firewall.

Alternatively, by modifying the Trusted Address Group, you can restrict access to certain machines only. For example, changing the

Which One Should You Choose?

Any of the three will do the job quite nicely but if you're a rank beginner, go for ZoneAlarm or Sygate Personal Firewall. They are easy to set up and you don't have to learn about ports and network protocols.

Those of a more technical bent might prefer Tiny Personal Firewall. It's more flexible that the other two and allows you to create and tightly edit your own packet-filtering rules – provided you have the know-how, of course. Alternatively, you can let the wizard create the rules for you and then edit them afterwards.

Our advice is to choose the firewall that best suits your needs and stick with it. But what ever you do, don't install multiple firewalls on your PC or you'll get all sorts of foul-ups. And that applies even if you have only one firewall running.

For example, having both Sygate Personal Firewall and Tiny Personal Firewall installed (but not running) prevented both Internet and email access with ZoneAlarm set for high Internet security. Uninstalling both SPF and TPF restored normal operation.

Which one was causing the conflict? We didn't bother to investigate but it does indicate the sorts of problems that can occur if you install multiple firewalls. Don't do it.

If you do want to try a different firewall, uninstall the previous firewall first.

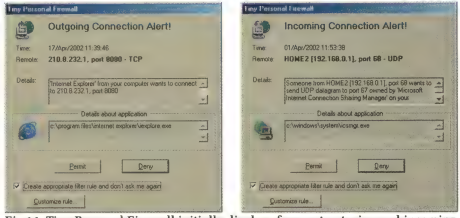

Fig.14: Tiny Personal Firewall initially displays frequent outgoing and incoming connection alerts until it learns the ropes. The incoming alert here is from a machine on the local network.

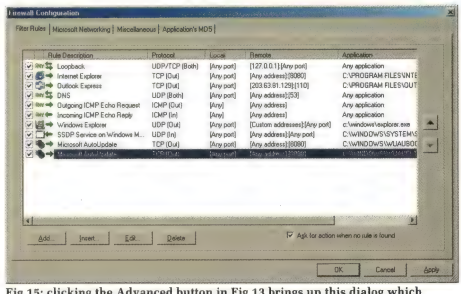

Fig.15: clicking the Advanced button in Fig.13 brings up this dialog which shows all the current filter rules. You can add, edit or delete rules as necessary.

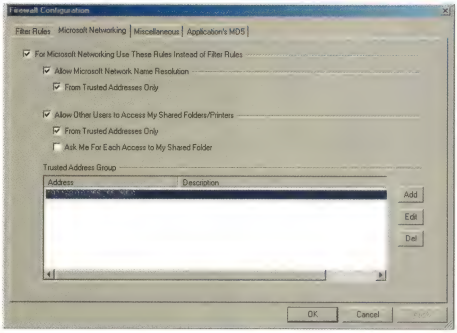

Fig.16 (above): the Microsoft Networking section makes it easy to grant or deny access for machines on the local network. Note that any settings here take precedence over the filter rules.

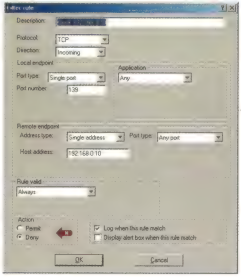

Fig.17(right): the Filter Rules dialog is very flexible and lets you create rules based on protocol, packet direction, ports and application. You can even set up scheduling and logging from here.

trusted address group to 192.168.0.0 -192.168.0.10 restricts access to machines with IP addresses in this range. Machines with an IP of 192.168.0.11 or higher are blocked.

If you're not on a local network, just check "For Microsoft Networking Use These Rules Instead Of Filter Rules" and clear all other check boxes under the Microsoft Networking tab. This simple step prevents your computer from being identified by machines on an external network and denies access to any shared resources (not that you should have any for a standalone machine).

Earlier versions of TPF did not include the "Microsoft Networking" tab, which meant that you had to set up the filter rules yourself if you wanted to share resources. We'll show you how to do that next month.

Living by the rules

One thing that's important to remember here is that the rules set up under Microsoft Networking override any Filter Rules that you may create. This means that it's futile creating separate Filter Rules to block certain IP addresses (as in Fig.17) if they have already been granted access under Microsoft Networking.

In short, the rules listed under Microsoft Networking will win out every time.

If you wish to create your own Filter Rules for the local network, make sure that they will not be overridden by the Microsoft Networking rules. In some cases, it may be easier to disable the Microsoft Networking rules altogether (just clear the top check box).

Top-down rule order

Another thing that's important to remember is that the Filter Rules operate in a "top-down" order. In other words, filter entries at the top of the table take precedence over entries lower down.

This works as follows: let's say that you create a rule that allows access for machines with IP addresses from 192.168.0.1 to 192.168.0.20 but then have a rule further down that blocks access for 192.168.0.10 only. Guess what? – 192.168.0.10 will still have access through the firewall since the top rule "clobbers" the rule further down.

Once permission for something has been granted (or denied), you cannot change it with a rule further down the list.

The answer in this case is to move the "blocking" rule up the list, so that it is above the other rule. The blocking rule then blocks 192.168.0.10, with the following rule then allowing access for the remaining machines.

That said, you wouldn't normally block access for individual machines on a local network by creating separate Filter Rules. Instead, it's far easier to block access by leaving the relevant IP addresses out of the Trusted Address Group under the Microsoft Networking tab.

We'll take a closer look at creating your own rules for Tiny Personal Firewall in next month's issue.

Firewall Downloads

Firewall	Operating System	File Size	Download Site
ZoneAlarm 2.6.362	Windows 95/98/Me Windows NT/2000/XP	2.92MB	www.zonelabs.com
Sygate Personal Firewall 5.0	Windows 95/98/Me Windows NT/2000/XP	4.74MB	www.sygate.com
Tiny Personal Firewall 2.0.15	Windows 95/98/Me Windows NT/2000/XP	1.42MB	www.tinysoftware.com
Spyware Checking Software			
Lavasoft Ad-aware 5.71	Windows 95/98/Me Windows NT/2000/XP	0.87MB	www.lavasoftusa.com

A Few Basic Security Measures

Here are a few other security measures that you can take to protect your PC, whether you run a firewall or not.

(1) Make sure that "File And Printer Sharing For Microsoft Networks" and "Client For Microsoft Networks" are NOT bound to your Internet adapter (note: this advice applies whether you are on a local network on not).

For example, if you use a modem to connect to the Internet, you should unbind these services from your Dial-Up Adapter. To do this, right-click My Network Places (or Network Neighborhood), select the TCP/IP entry for the Dial-Up Adapter, click Properties, click the Binding tab and clear the check boxes.

(2) If you don't require Internet access for any other machines on the network, consider using NetBEUI as your networking protocol for file and printer sharing. TCP/IP can then be removed from these other machines altogether, thus effectively closing NetBIOS ports 137-139.

Both TCP/IP and NetBEUI will be required on the Internet machine but make sure that TCP/IP is bound only to your Internet adapter.

If you're not running a network, remove "Client for Microsoft Networks" from your PC entirely.

(3) Visit Steve Gibson's Shields-Up site at www.grc.com for lots of good advice on security measures.

(4) Check the Microsoft Update site regularly and install any critical updates that involve security.

Fig 18: make sure that Client for Microsoft Networks and File and Printer Sharing are not bound to your Internet adapter.

(5) Install a "spychecker" program such as Ad-aware from Lavasoft. This can detect and remove any "spyware" and "adware" programs that have snuck in.

Ad-aware is a free utility from www.lavasoftusa.com but be sure to regularly update its signature file (called "reflist.sig"). A related utility – refupdate.exe – can do this for you automatically.

(6) Use the PCFlank site at http://tools.pcflank.com to scan your machine for Trojans. You should also use this site (or one of the other test sites) to scan for open ports and to test the effectiveness of your firewall.

(7) Use a good anti-virus program and regularly update its virus definitions file.

(8) Don't run email attachments unless they have been virus checked and you know what they are.

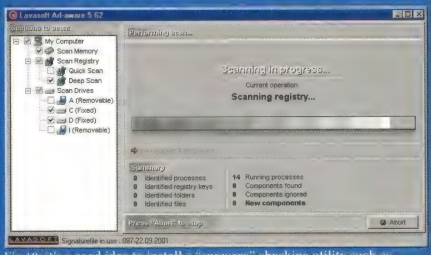

Fig 19: it's a good idea to install a "spyware" checking utility such as Lavasoft's Ad-aware but be sure to keep its signature file up-to-date.

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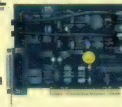

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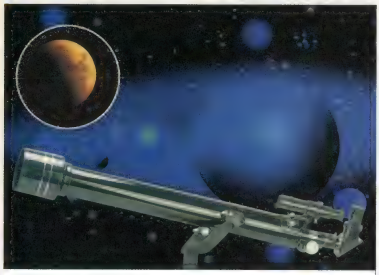

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T 1374

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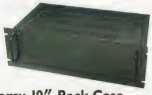

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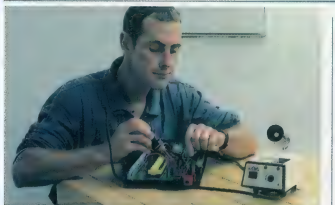

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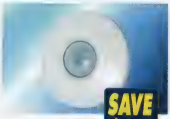

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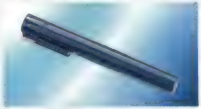

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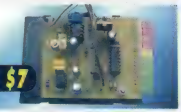

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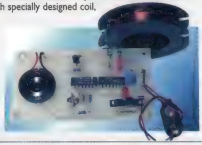

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For use with universal brush-type motors, eg electric drills, routers, circular saws etc. Rating of up to 10A @ 240V. Constructed in safe, earthed diecast case. Power source required: 240V AC. Supplied with all components, PCB, pre-punched die-cast case, and screened front panel.

K 3087

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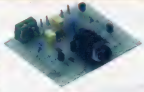

Headphone Amplifier Kit	K 5611	$17.88	SILICON CHIP May '02
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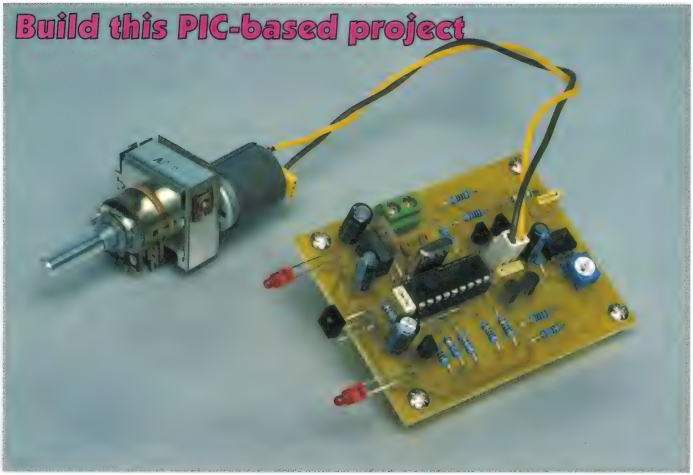


Remote volume control for stereo amplifiers

Does your amplifier have a remote volume control? It doesn't? How can you bear it? It must be tough! Add this remote volume control to your stereo amplifier and life will never be the same again.

By JOHN CLARKE

LET'S FACE IT, everything has remote control today and if your stereo amplifier doesn't at least have a remote volume control, life must be really tough. Fortunately, we have the solution. We've slaved away to produce this infrared volume control and it can be added to most stereo amplifiers, provided you can find space behind the front panel for the motorised stereo potentiometer.

When installed, the motorised potentiometer can be used in the normal way; just grab the knob and wind it up to set the volume. Or, by pushing the "UP" button on the handheld remote, it will be rotate by itself (as if by magic) and you can set the volume from your couch. Of course, you may now put on another 15kg of weight because you no longer have to get up to change the volume but that is a small price to pay, isn't it? We think so anyway.

Adding remote control to a stereo amplifier involves replacing the original dual-gang potentiometer with a motorised version and installing a small controller PC board inside the amplifier as well. It needs a 9-15V DC supply which should be available within the amplifier. You can control

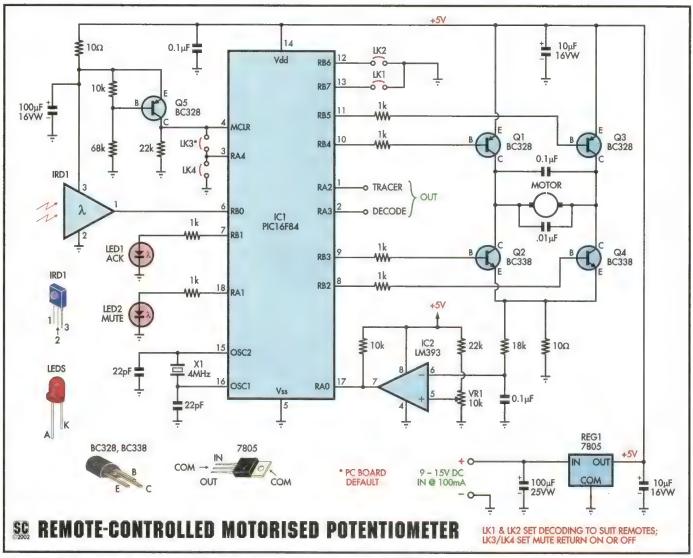


Fig.1: IRD1 picks up infrared signals from the remote control and feeds the demodulated data to the PIC microcontroller (IC1). IC1 in turn controls the motorised potentiometer via transistors Q1-Q4.

it using a standard preprogrammed remote control.

Using the remote

Hey, we know you don't need lessons in pushing buttons but humour us for a moment. After all, having slaved to produce this project, we need some gratification in telling the story.

OK, when using the remote control, the standard volume up and down pushbuttons cause the motorised potentiometer to rotate clockwise or anticlockwise, as you would expect. If you keep pressing the up or down button, the motor can only drive the potentiometer so far and then an internal clutch slips so that no damage is done.

The overall time taken for the pot shaft to rotate clockwise from minimum to maximum is nine seconds and it takes the same time in the opposite direction. However, just pressing the up or down button is rather coarse and may not provide sufficiently precise setting of the volume. Consequently, we have provided a more precise method using the "channel up" and "channel down" buttons on the remote unit.

Each time you press one of these buttons, the volume knob moves by about 1° of rotation. Alternatively, holding one of the buttons down will cause the volume knob to rotate from minimum to maximum in 28 seconds.

This slimline unit from Altronics (Cat. A-1013) can be used but lacks a mute button.

Muting as well

A feature of this unit is volume muting, something that many commercial amplifiers don't have. Here it is done automatically using the Mute pushbutton on the remote. Push the Mute button once and the volume knob rotates fully anticlockwise. During this time the Mute LED flashes and then remains on after the volume knob has reached its minimum setting.

Parts List

1 PC board, code 15106021, 74 x 57mm
1 Alpha dual-ganged 20kΩ (or 50kΩ) log motorised pot
1 DIP 18-pin IC socket (for IC1)
1 2-way PC-mount screw terminal block (5.08mm pin spacing)
1 4MHz crystal (X1)
1 2-way pin header (2.45mm spacing)
1 2-way header plug (2.54mm spacing)
4 M3 tapped x 10mm Nylon standoffs
8 M3 x 6mm screws
1 300mm length of hookup wire
1 10kΩ (code 103) horizontal trimpot (VR1)

Semiconductors

1 PIC16F84 programmed with "motorpot.hex" (IC1)
1 LM393 dual comparator (IC2)
1 infrared decoder (IRD1)
1 7805 5V regulator (REG1)
3 BC328 PNP transistors (Q1,Q3,Q5)
2 BC338 NPN transistors (Q2,Q4)
2 red LEDs (LED1,LED2)

Capacitors

1 100µF 25VW PC electrolytic
1 100µF 16VW PC electrolytic
2 10µF 16VW PC electrolytic
3 0.1µF MKT polyester
1 .01µF MKT polyester or ceramic
2 22pF ceramic

Resistors (0.25W, 1%)

1 68kΩ	2 10kΩ
2 22kΩ	6 1kΩ
1 18kΩ	2 10Ω

WHERE TO GET THE SOURCE CODE

For those interested in programming their own microcontroller, the source code (motorpot.asm) can be downloaded from our website: **www.siliconchip.com.au**

Pressing the Mute button again will return the volume to its previous setting; well, within 1.5° of rotation.

How does it do that? The drive controller actually measures the time the volume knob takes to reach the minimum setting. Then, when the Mute button is pressed again to restore the volume, power is applied to the motor drive for the same amount of time.

During the muting and return, the process can be stopped by pressing the Mute button again or using one of the volume buttons.

No noise

The control circuitry is designed so that it doesn't introduce any noise into any sensitive sections of the amplifier into which it is installed. Normally, when there is no IR signal being transmitted by the remote, the circuit is quiescent and produces no noise. As soon as it receives an infrared signal it responds by driving the motorised potentiometer and then shuts down after about 1.2 seconds if it does not receive any further infrared signals.

The motor too is enclosed in a Mumetal shield which reduces any electrical hash caused by the sparking of the brushes against the commutator. A .01µF capacitor across the motor terminals prevents the hash signals being sent along the connection wires.

Circuit details

The complete circuit for this Remote-controlled Motorised Potentiometer is based on a PIC16F84 microcontroller. It monitors the demodulated infrared signal from the detector IRD1. It decodes the signal and drives the motor according to the code sent by the handheld remote.

IRD1 only has three leads but it is not a simple device; it is a complete infrared detector and processor. It picks up the infrared signal which comprises a series of 38kHz pulses. The signal is amplified to a constant signal level, fed to a 38kHz bandpass filter and then demodulated to produce a serial data burst which is fed to the RB0 input of IC1 at pin 6.

IC1 is programmed to recognise the RC5 Code. This is a standard infrared remote control code used by Philips and associated manufacturers.

The remote volume control can be operated on one of four codes within the RC5 Code. These are TV1, CD, SAT1 and SAT2. These are selected using links LK1 and LK2 at the RB7 and RB6 inputs of IC1. Both these inputs are pulled high using internal resistors in IC1 but can be pulled low with links LK1 and LK2. IC1 monitors the level of these inputs and uses the selected code to compare with the incoming serial data from IRD1. If the detected code is correct, the motorised potentiometer will be driven according to the pushbutton command sent by the remote control.

Motor drive

The motorised potentiometer is driven by four transistors (Q1-Q4) which are driven via the RB2, RB3, RB4 and RB5 outputs of IC1 via 1kΩ resistors. When the motor is off, the RB2-RB5 outputs are all set high. The high outputs at RB4 and RB5 switch off transistors Q1 and Q3 while the high outputs at RB2 and RB3 drive transistors Q2 and Q4 so that they are turned on. Both terminals of the motor are thus held low.

The emitters of Q2 and Q4 connect to ground via a 10Ω resistor. To drive the potentiometer clockwise, Q2 is switched off via a low level on RB3 and transistor Q1 is switched on via a low on RB4. Thus the lefthand terminal of the motor is taken to +5V via Q1 and the righthand terminal of the motor is low via Q4. To drive the potentiometer anticlockwise, Q1 & Q4 are switched off and Q2 & Q3 are switched on. Thus the righthand motor terminal is pulled to +5V via Q3 and the lefthand terminal is low via Q2.

The voltage across the motor is dependent on the voltage drop across the 10Ω emitter resistor of Q2 & Q4. Typically, the motor draws 40mA when driving the potentiometer and over 50mA when the clutch is slipping. Thus, the motor voltage is around 4.5-4.6V due to the 0.4-0.5V drop across the 10Ω resistor. Rated motor voltage is 4.5V.

Comparator IC2 monitors the voltage across the 10Ω resistor via a filter comprising an 18kΩ resistor and 0.1µF capacitor. This removes the commutator hash so that a smooth voltage is applied to the inverting input at pin 6. VR1 is adjusted so that the voltage at the non-inverting input at pin 5 is about +0.45V. When the motor is running normally, the 40mA drawn by the motor produces 0.4V across the 10Ω resistor.

Since this voltage is lower than the set voltage at pin 5, the comparator output at pin 7 is high. When the potentiometer reaches the end of its travel, the extra load from the slipping clutch raises the voltage across the 10Ω resistor to above the voltage set at pin 5. The comparator output at

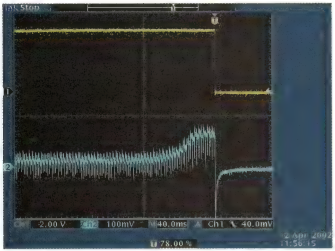


Fig.2: the top trace shows the motor drive voltage which is about 5V when the motor is running. The lower trace is the voltage across the 10Ω current sensing resistor. This is less than 50mV while the motor is turning the pot shaft but rises above 120mV when the endstop is reached. This is detected by IC2 and IC1 switches off the motor during muting.

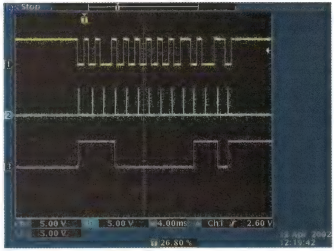


Fig.3: the top trace here shows the output from the infrared receiver (IRD1) when the Mute signal is being transmitted. The middle trace is the tracer signal as seen at pin 1 of IC1. IC1 monitors IRD1's voltage when the trace level is high and the resulting decoded IR signal is shown on the lower trace, as measured on pin 2 of IC1.

pin 7 then goes low. This is detected by the RA0 input of IC1 but this only happens during the Muting operation, so that the motor can be stopped immediately that pin 7 of IC2 goes low.

At other times, when the volume is being set by the Up or Down buttons, the RA0 input is not being monitored, so the clutch will begin to slip if the potentiometer is driven past its clockwise or anticlockwise limits.

The Acknowledge and Mute LEDs are lit when their respective RB1 and RA1 outputs are pulled high via their 1kΩ resistors. The Acknowledge LED lights when the RB0 input receives an infrared signal while the Mute LED flashes during the Mute operation and then stays lit while muted.

Pins 15 and 16 of IC1 are the oscillator inputs for the 4MHz crystal. The oscillator runs when first powered up for about 1.5 seconds and also whenever an infrared signal is received at RB0 and then for 1.5 seconds after the last receipt of signal. Oscillator shutdown ensures that there is no radiation of noise into sensitive audio circuitry when the volume control is not being altered.

Transistor Q5 provides a reset for IC1 should the supply at pin 14 drop below a certain value. It works as follows. The emitter of Q5 is supplied with close to +5V via the 10Ω resistor. Q2's base voltage is held at 0.6V below the emitter via the 10kΩ and 68kΩ resistors connecting across the 5V supply. With Q5 switched on, the collector is pulled high and so pin 4 is also held high at around +5V. IC1 can then operate normally.

Should the supply drop below +4.68V, Q5 will turn off and the 22kΩ collector resistor will pull pin 4 of IC1 low, placing IC1 in its reset condition. The same process happens at power up. As the supply is switched on, pin 4 is held low via the 22kΩ resistor until the supply goes above 4.68V.

Note that the RA4 input is tied to pin 4 via link LK3. This enables the "mute return" feature. Connecting the RA4 input to ground by cutting the track to pin 4 and soldering a bridge to ground will indicate to IC1 that the "mute return" feature is disabled.

RB6 and RB7 are for different infra-

A Brief Primer On RC5 Code

This standard code comprises 14 bits, with the first two as high level start bits. The third bit is the toggle bit which can be either high or low and toggles between a high or a low each time a key is pressed on the remote control.

The toggle bit does not change if one of the keys is continuously pressed. It is used to inform the decoder whether a key was pressed continuously or pressed more than once. The following bits are five address bits and six keycode or command bits. The address bits define what item of equipment is being controlled, while the command bits determine what function is to be carried out via remote control.

Finally, the bits are separated by 1.778ms and the code repeats every 113.778ms.

MAIN FEATURES

- Infrared remote control
- Volume Up and Down
- Special precision volume adjustment
- Muting facility (automatic volume down)
- Mute return (automatic volume up)
- Uses commercial preprogrammed remotes
- Original knob volume control movement retained
- Optional mute return disable
- Acknowledge indicator
- Mute indication
- No switching noise injected into amplifier

CHOOSING A REMOTE CONTROL

The G-1223 IR remote is available from DSE.

This Remote Volume Control should work with just about any preprogrammed IR remote transmitter that can control a Philips TV set, a satellite receiver, a VCR or a CD player. It's just a matter of programming it by following the instructions (see text).

Suitable IR remote controls include: Altronics Cat. A-1013 and Cat A-1009; Dick Smith Cat. G1223; and Jaycar Cat. AR-1073 (Select 1) and Cat. AR-1710 (Big Shot 3).

If you already have a multi-function remote control (ie, one that can control a TV set, a VCR and a satellite receiver), then you don't need to buy another remote. Just use the satellite function or some other function (eg, VCR or CD) for the Remote Volume Control.

The Altronics Cat. A-1013 (top) and Cat. A-1009 IR remotes are both suitable but note that the A-1013 has no mute button.

red coding options. The default selection is when both RB6 and RB7 are held high via their internal pullup resistors. This selects the TV1 infrared remote control code which will be suitable for most applications. However, this code may also operate your TV and so we have provided options to select another code to prevent this from happening.

Table 3 shows the linking options to select the CD, SAT1 or SAT2 codes. As an example, tying LK2 to ground via a solder bridge will set the code to CD.

Power requirement for the circuit is a 9-15V DC supply which can deliver up to 70mA. REG1 sets the supply to +5V, suitable for IC1, IC2 and IRD1. Capacitors at the input and output of REG1 provide filtering of the supply, while the 10µF capacitor across IRD1 prevents this device from feeding hash back into the 5V rail.

Table 1: Capacitor Codes

Value	IEC Code	EIA Code
0.1µF	100n	104
.01µF	10n	103
22pF	22p	22

Construction

The Remote-Controlled Motorised Potentiometer is assembled onto a PC board coded 15106021 which measures 74 x 57mm.

Important note: before you even purchase the kit for this project, you need to ensure that there is sufficient space behind the existing volume control of your amplifier. The motorised potentiometer requires considerable room (depth).

In some cases, you might be able to make more room by locating parts onto the underside of existing PC boards.

In addition, there must be room for the additional PC board inside your amplifier and a DC supply of between +9 and +15V which can deliver up to 70mA when required. Standby current for the circuit is around 15mA rising to 60-70mA when the motor is running.

You can begin assembly by checking the PC board for any shorts between tracks or hairline breaks. Also, check the hole sizes for each component. In particular, the PC mounting screw terminals need to be 1.5mm diameter, while the 2-way pin header for the motor connections requires 1mm diameter holes. Corner mounting holes should be 3mm in diameter.

Install the two wire links and the resistors first, using the colour code table as a guide to selecting values. Insert and solder IC2 and the socket for IC1, taking care with orientation. Capacitors and transistors can be mounted next. Be sure the electrolytic capacitors are installed with the correct polarity and take care with the transistors as there are two different types. Q2 and Q4 are BC338s.

Next, install VR1, REG1, the screw terminals and the 2-way pin header.

The LEDs and IRD1 are located on the edge of the PC board so that they can be inserted into suitable holes in the front of the amplifier.

If there is insufficient room for this PC board to be placed near the front panel, you can use a satellite board which carries just IRD1 (the infrared receiver) and two LEDs. We will have more details on this next month, when we describe how this project is installed in the Ultra-LD 100W Stereo Amplifier.

Next, solder the .01µF ceramic ca-

Table 2: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	68kΩ	blue grey orange brown	blue grey black red brown
2	22kΩ	red red orange brown	red red black red brown
1	18kΩ	brown grey orange brown	brown grey black red brown
2	10kΩ	brown black orange brown	brown black black red brown
6	1kΩ	brown black red brown	brown black black brown brown
2	10Ω	brown black black brown	brown black black gold brown

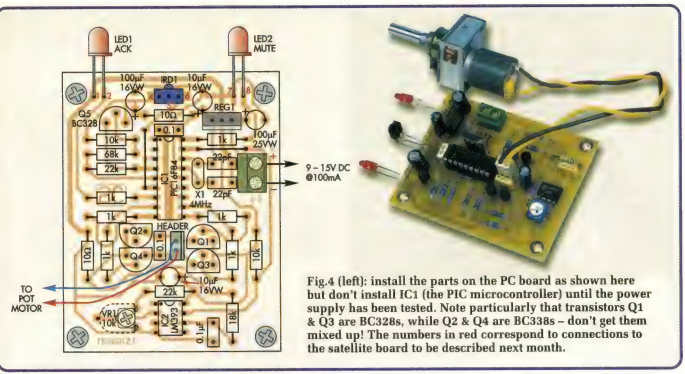


Fig.4 (left): install the parts on the PC board as shown here but don't install IC1 (the PIC microcontroller) until the power supply has been tested. Note particularly that transistors Q1 & Q3 are BC328s, while Q2 & Q4 are BC338s – don't get them mixed up! The numbers in red correspond to connections to the satellite board to be described next month.

pacitor and connection wires to the motor terminals of the motorised potentiometer. Crimp the other ends of the wires to the 2-way pin header plug pins and insert the pins into the header plug shell. Then attach the motor cable to the motor pin header terminals on the PC board.

Testing

Before installing IC1 into its socket, connect power to the screw terminals on the PC board using a DC supply of 9-15V. Now measure the voltage between pins 5 & 14 of IC1's socket – you should get a reading between 4.8V and 5.2V. If this is correct, switch off the power and insert IC1 into its socket.

Further testing requires a universal remote control. These range from single TV remote controls with limited functions to elaborate models capable of operating many different types of equipment.

Note that simple TV remote controls will only operate this project with the code selected for TV. If you have a Philips TV set located in the same area as your amplifier, the remote control will probably operate the TV as well. In this case, you will need to select a different code which means that a multi-item remote control will have to be used.

Examples of TV-only remote controls are the Jaycar AR-1703 and the Dick Smith G1223. Multi-item remote controls include the Altronics A-1009 and the Jaycar AR-1710.

Programming the remote

Program your remote control initially for a Philips brand TV by following the instructions supplied with the unit. In most cases, programming means that the set button is pressed along with the item which is to be operated. In other words, **press SET and TV together and enter a number quoted for a Philips TV set.** In this case, the Jaycar AR-1710 and Altronics A-1009 and A-1013 remote controls use the number 191; the DSE G-1223 uses 11322; and the Jaycar AR-1703 uses 11414.

If you are using a different remote control, select a number for a Philips TV set. If it does not operate the motorised potentiometer, try another number for a Philips TV.

Now rotate VR1 fully clockwise and check the motor turns the potentiometer clockwise when the volume up and channel up buttons are pressed. That done, check that the potentiometer runs anticlockwise with the volume down and channel down buttons. If the potentiometer turns in the wrong direction, reverse the leads connected to the motor. Check that the Acknowledge LED lights each time you press a button on the remote.

Now press the Mute button and wait until the motor winds the pot fully anticlockwise. Now adjust VR1 clockwise until the motor stops. Press mute again or the volume up button to turn the potentiometer clockwise. Now press mute again and check that the motor stops when the potentiometer reaches its end of travel.

Note that there is a timeout of 13 seconds which will stop the motor after the mute has been activated. So do not take too long in adjusting VR1 or the timeout will stop the motor rather than the adjustment of VR1. Note also that with a new motorised potentiometer, the clutch will require a little wearing in to spread the lubricant in

The Jaycar AR-1073 (top) and AR-1710 IR remotes are also suitable.

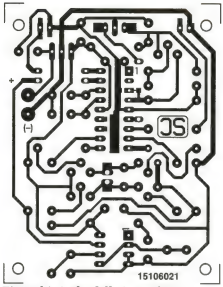


Fig.5: this is the full-size etching pattern for the PC board.

the slipping sections evenly. This can be done simply by turning the pot shaft by hand a few times before use. Readjust VR1 for best results.

When the motor stops reliably at the anticlockwise end stop, press the mute after it reaches its fully anticlockwise position. This should cause the potentiometer to accurately return to its previous position. If the mute return feature is not required, cut the thinned track connection between pins 3 & 4 of IC1 and join pin 3 to the ground with a bridge of solder. (The ground is the heavy copper track that runs down the centre of IC1).

Changing the codes for the infrared transmission is done by soldering bridge connections between pin 13 of IC1 and ground and pin 14 of IC1 and ground, as detailed in Table 3. For example, connect pin 13 (LK1) to ground to select SAT 1.

The relevant codes for the Altronics A-1009/A-1013 and Jaycar AR-1710 remotes are 651 for CD, 424 for SAT1 and 425 for SAT2.

Installation

As noted, the motorised potentiometer replaces the original volume control in the amplifier. There needs to be sufficient room behind the potentiometer for the motor and gearbox section to fit without fouling any part of the amplifier. You may need to shorten the shaft of the potentiometer to suit the amplifier's volume knob. Or possibly the knob may need changing or modifying to suit the shaft.

After installing the potentiometer, check that the metal body of the motorised section is connected to chassis; use a multimeter set to the low "ohms" range.

The motorised potentiometer is connected to the amplifier with the same connections as the original potentiometer. Typically the anticlockwise end of the potentiometer connects to ground or to the common point of the amplifier, the clockwise or top end of the potentiometer connects to the preamplifier output via a coupling capacitor and the wiper connects to the power amplifier.

Note that the coupling capacitor that connects to the top end of the potentiometer may need to be changed if the value of the motorised potentiometer is different to the original.

In practice, though, if the new potentiometer is only twice or half its original value, there should be no need to change the capacitor.

For larger variations in potentiometer value, it may be necessary to change the coupling capacitor value. This is because the low frequency response of the amplifier may be altered. The new value of capacitance is calculated by scaling the original value by the ratio of the difference between the original potentiometer value and the new pot value. So if the new pot value is smaller than the original, make the capacitor value larger by the same amount.

If the new pot value is larger than the original then no changes are necessary.

Find a position for the remote control receiver PC board to fit into the amplifier case. The location should take into account the fact that IRD1 and the LEDs need to protrude through small holes in the amplifier front panel.

Table 3: Link Options

LINKS:	LK1	LK2	CODE
TV1*	OUT	OUT	026, 191
CD	OUT	IN	651
SAT1	IN	OUT	424
SAT2	IN	IN	425

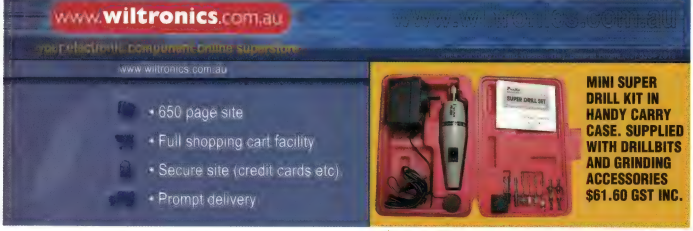
*PC BOARD DEFAULT

This table shows how to change the infrared code function using links LK1 & LK2 (see text)

Satellite board

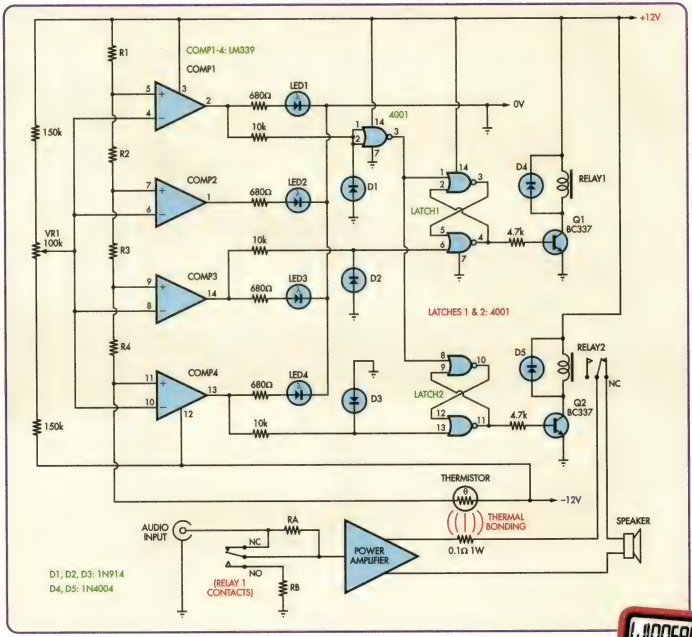
As mentioned before, if there is insufficient room for the PC board close to the front panel, you can use the satellite PC board which carries the infrared receiver (IRD1) and LEDs only. We'll describe the satellite board next month.

Finally, you need to find a suitable DC power supply connection for the infrared receiver PC board. The voltage required is 9-15V DC at up to 70mA. Be sure to connect the correct polarity to the power terminals of the receiver PC board. **SC**



CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Loudspeaker protector monitors current

This circuit uses a 0.1Ω 1W resistor connected in series with the output of a power amplifier. When the amplifier is delivering 100W into an 8Ω load, the resistor will be dissipating 1.25W. The resulting temperature rise is sensed by a thermistor which is thermally bonded to the resistor.

The thermistor is connected in series with a resistor string which is monitored by the non-inverting (+) inputs of four comparators in an LM339 quad comparator. All of the comparator inverting inputs are connected to an adjustable threshold voltage provided by trimpot VR1.

As the thermistor heats up, its resistance increases, raising the voltage along the resistor ladder. When the voltage on the non-inverting input of each comparator exceeds the voltage at its inverting input, the output switches high and illuminates the relevant LED.

NOR gate latches are connected to the outputs of the third

Continued from previous page . . . and fourth comparators. When the third comparator switches high, the first latch is set, turning on Q1 and relay 1. This switches in an attenuation network (resistors RA & RB) to reduce the power level.

However, if the power level is still excessive, comparator 4 will switch, setting its latch and turning on Q2 and relay 2. This disconnects the loudspeaker load. The thermistor then needs to cool down before normal operation will be restored.

The values of R1-R4 depend on the thermistor used. For example, if a thermistor with a resistance of 1.5kΩ at 25°C is used, then R1 could be around 1.5kΩ and R2, R3 and R4 would each be 100Ω (depending the temperature coefficient of the thermistor).

The setup procedure involves connecting a sinewave oscillator to the input of the power amplifier and using a dummy load for the output. Set the power level desired and adjust trimpot VR1 to light LED1. Then increase the power to check that the other LEDs light at satisfactory levels.

David Devers,
Kingsbury, Vic.

Modification to Smoke Alarm

The Smoke Alarm Monitor described in the January and February 1997 issues does not operate smoke alarms which have test inputs which do not connect to ground; eg, the Family Guard smoke alarm.

The solution is to use an optocoupler so that the test input to the smoke alarm can be triggered without reference to the ground terminal. This involves modifications to the original Additional Circuit which needs to be installed into each smoke alarm. The internal LED of the optocoupler is driven via transistor Q4. Originally this transistor shorted the test switch on the smoke alarm.

Note that the polarity must be correct, with the collector of the optocoupler (pin 5) going to the more positive terminal of the test switch. This polarity can be determined using a multimeter across the test switch.

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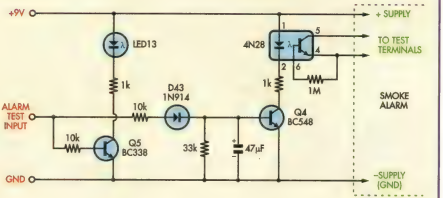
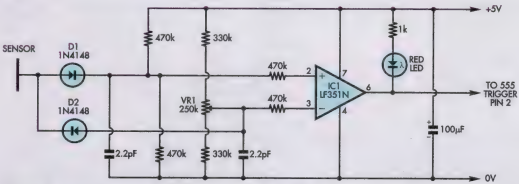




This body charge detector circuit is based on an LF351 FET-input op amp. Note that the 0V side of the circuit must be taken to earth (eg, a metal stake driven into the ground).

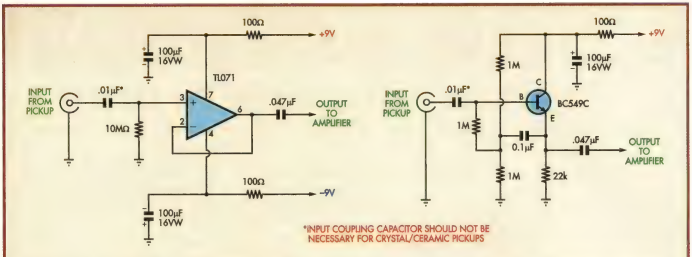
Body charge detector

It is well known that through such simple everyday activities as walking on a carpet or moving in a chair, the body accumulates a static charge – sometimes many thousands of volts.

Due to its extreme sensitivity, this circuit will detect not only such charges but also EMF-induced voltages in the body, which are generally far smaller. This means that, whether you happen to be "charged up" on any particular day or not, your body will almost certainly trigger this circuit.

An interesting twist is that the sensor does not need to be made of metal. Provided it is isolated from ground, the sensor can be any conductor, including a plant in a pot.

The circuit is a comparator based



Preamp stage for ceramic phono cartridge or violin pickups

While we have published a number of variations on a standard RIAA preamplifier for magnetic phono cartridges, we have not published a preamp stage for ceramic phono cartridges. Typically, these were supplied as turnover cartridges in record changers but there were higher quality versions such as the Decca Deram.

These phono cartridges are piezoelectric devices which require a very high input impedance. Similarly, violin pick-ups made by Fishman, Barcus Berry and others are piezo devices. These two circuits have been requested for a violin pickup but could equally well suit a ceramic or crystal pickup.

The op amp circuit uses a TL071 connected as a voltage-follower. It can run from a battery supply of ±9V. The alternative transistor circuit uses a BC549 connected as an emitter-follower but with bootstrapping of the input bias network to provide a high input impedance. Both circuits have input coupling capacitors but since the transducers are capacitive (ie, piezo) they could possibly be omitted.

Both circuits will probably need to be followed by further gain, depending on the output level. For a violin pickup, a parametric equaliser is also recommended, and for this we would suggest the 3-band parametric equaliser published in the July 1996 issue of SILICON CHIP. With a slight change to the feedback of the first op amp in this circuit, the extra gain required could also be provided.

SILICON CHIP.

on an LF351 FET-input op amp (IC1). The has the benefit of a high impedance input which is crucial for detecting a static charge.

The other aspect which is crucial is that the 0V side of the circuit must be connected to earth (eg, a metal stake driven into the ground). Without the grounded connection, the circuit will yield poor results.

Notice that the sensor connections are taken through diodes D1 and D2. This means that both negative and positive charges will cause the voltage at IC1's inverting input to exceed that of the non-inverting input (the voltage at the inverting input rises or that at the non-inverting input falls).

Trimpot VR1 and the two 470kΩ resistors across the supply are used to set the inverting and non-inverting inputs (pins 2 and 3) at around half-supply (ie, +2.5V), while the two 470kΩ input resistors protect IC1 against damage from static. The sensitivity of the circuit is adjusted by VR1.

While higher static charges will brightly flash the red LED, small and very rapid discharges through the sensor may barely illuminate it. The way around this is to feed the output at pin 6 directly to the trigger input (pin 2) of a standard 555 monostable timer IC. This would then offer a clearer indication of triggering.

This circuit could prove particularly useful as an indicator of static charge before handling sensitive components.

Thomas Scarborough,
Cape Town,
South Africa. ($35)

CONTRIBUTE AND WIN!

As you can see, we pay good money for each of the "Circuit Notebook" contributions published. But now there's an even better reason to send in your circuit idea: each month, the best contribution published will win one of these superb Wavetek Meterman 85XT true RMS multimeters - valued at around $380! So don't keep that brilliant circuit secret any more: send it to SILICON CHIP and you could be a winner!

Contributions must be your own original work or a major adaptation and not published elsewhere nor submitted for publication elsewhere. SILICON CHIP's decision is final.

SERVICEMAN'S LOG

This little telly came to town

The pigs went to market when farmer Hilliard's "telly" came to town for a service. It wasn't all that easy to fix though, as this little "telly" came with bits from the farmyard.

Mr Hilliard lives way out in the sticks and I wasn't about to go on safari to visit his farm and fix his telly – even though the thought of a good holiday does appeal.

Obligingly, the next time he was in the Big Smoke, he brought in his 1991 Panasonic TC 68A61 (M16M chassis) duly hog-tied to the back of his ute.

Fortunately, the pigs had already gone to market – though their presence was never too far away. Even so, getting the heavy set (43kg) off the tray was life-threatening as I was very nearly sent skittling on their calling cards.

Finally, it reached my workshop bench with the comment "she's dead!" I said that the set was somewhat ancient and didn't look its best but Mr Hilliard dismissed this as city-folk talk and just mumbled that his ute was much older and still going fine.

Well, as far as I was concerned, provided that he understood that the set was no longer under warranty, I would do my best to restore his telly.

I removed the back and a cursory glance inside made me wonder whether he had brought it from the farmyard or whether the farmyard was still inside the set. There was so much dust, straw and unmentionables that I almost missed finding the mouse nest between the main chassis and the front control board.

Fortunately, its owner had already left. Not being an expert on mice, I could only conjecture at its size – how could even a small field mouse find its way through the tightfitting shell of the cabinet, let alone build its nest of wood shavings inside? The other drama of this discovery was, of course, the mouse droppings, seeing as the set didn't have a sewage system.

If one can find a plus side to this story so far, it could only be that everything inside the set was at least dry and the air compressor gun didn't have too much trouble in removing the waste of our resident rodent. But, as far as I am concerned, the only good mouse one can find is normally attached to a computer.

Fortunately, the corrosion was limited to areas where there was not a high concentration of components and most of it cleaned up pretty well. But to anyone who knows the Panasonic M16M chassis, access to the motherboard can only be described as poor due to the congestion of modules, heatsinks and cables, especially around the deflection D board.

Briefly, in a power failure situation on this model, caution has to be one's middle name. Most of the faults are well-known and documented but nevertheless one is normally advised to replace all the common parts listed on their fault list and then do a "dry run" by measuring everything passively

EVEN SO, GETTING THE HEAVY SET OFF THE TRAY WAS LIFE THREATENING...

with a multimeter. That done, you then do a "trial run" using a variac with the line output stage disconnected and a globe substituted. It is also necessary to disconnect many of the protection circuits and this is done by removing a single "lynch pin" diode – D560.

Finally, after a series of tests, you can reassemble it all and do a full load test.

In this case, the set wasn't completely dead but was instead trying to come on and then switching to standby. However, you have to be careful in determining this, as the set has a "last power" feature. This means that whatever mode the set was in when it was switched off, it will come back on in that same mode; eg, if you switched to standby with the remote, it will come back on in this mode. If, however, the power was switched off, it will come straight back on again.

I could measure the set trying to come on at +140V on test point TPD1 and similarly there was 12V across D883 before it closed down. The 5V rail was a bit low on TPD5, so I changed C885 and C889 (both 330µF 16VW) and this then gave the correct 5V rail.

On switch-on, you could hear the EHT static build up and there seemed to be no obvious sign of stress anywhere in the set, so I felt I could jump a couple of stages and risk firing it up with D560 disconnected. This disables several stages of protection triggering, including: Q820 via R833 (140V overvoltage); Q806 via R829 (140V overcurrent); Q557 via R577 (vertical output overcurrent); Q807 via R832 (5V, 12V & 15V overcurrent); Q553 via R574 (beam current, if fitted – not so in this case); D590 (horizontal output overcurrent); and D830 (12V short circuit).

The transistors listed here are all PNP types and their collectors must normally all be at 0V to ensure that Q554, Q555 and D560 are switched off for the set to come on.

Though I was taking a considerable risk, I was very lucky in that the set came on with a good picture and sound and with all functions working. All the voltage rails at the 11 test points were correct, so I had a problem(s) with the safety protection circuits – but which one?

Items Covered This Month

- Panasonic TC68A61 (M16M).
- RCA R14GG8RA (TX807).

The only way to determine this was to reconnect D560 and disconnect each collector resistor to the 0V protection rail. However, locating and disconnecting each in turn was harder than you can imagine because the access was poor and the component numbering was hard to read.

Fortunately, Lady Luck was with me because removing R833 to Q820 quickly pointed me in the right direction. I followed the base circuit to the anode of D830, the 12V rail sensor. This diode was OK but the voltage on its anode seemed too low at 1.53V. This is also connected to a resistive voltage divider off the 140V rail and Ohm's Law told me I should expect about 5.2V at this point.

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The first resistive leg in this divider consists of two 165kΩ resistors connected in parallel (R836 and R856). However, when I desoldered them, both were open circuit. The only problem is that 165kΩ is not even in the E24 range. I could either order them in (part No. ERO50CKF1653) or I could make up the correct value by connecting 82kΩ and 470Ω resistors in series. The latter option seemed to be the easiest course as I didn't think that the 30Ω difference would be significant.

Anyway, that fixed the problem immediately. The set came on and performed perfectly.

On the 33-inch version of this set, there is a "High Voltage Stabilisation" test procedure but on this model you can only activate the Self Check Mode by simultaneously pressing "OFF TIMER" on the remote and "VOLUME" on the TV. This gave an OSD (On Screen Display) 1 OK, 2 OK and three other pairs of numbers (82, F3 and D6) in the options hexadecimal for this model set, which all checked out OK with the service manual.

I let the set soak test before contacting our erstwhile farmer to collect it.

The only major unsolved riddle of this repair is how the mouse got in and out of the set through the tiny grille vents. Can anyone enlighten me?

Postscript

As a postscript, we are suddenly getting complaints for blue screen muting on this series of Panasonic TVs. We are not certain whether this is due to a fault condition yet to be identified in the set, or whether it needs to be modified for Macrovision, etc.

The problems seems to occur only with certain VCRs (the new generation of extra long play), tapes and TV reception conditions. In particular, it is noticeable with playback cue and review, Macrovision recordings and digital co-channel interference.

In all instances, the horizontal sync pulses are reduced or distorted, resulting in the picture muting out.

The only work around we can do at present is to turn the Blue background mute off, either with the "DISPLAY" button on the set or the "PNR" (Picture Noise Reduction) button or the "GAME POSITION" on the remote control to improve the poor signals. I would be very interested if anyone know if there is a modification and/or a fault that might require attention.

The French connection

I always thought that RCA (Radio Corporation of America) was an American home-brand name only – like Zenith. In fact, the only time we get to see the name regularly in Australia is on recordings like RCA Victor.

Anyway, when I first saw this RCA TV, I initially assumed that it was an American-designed and made set. In actuality, it was manufactured by Thomson – a French-owned company which is now probably the largest producer of TV sets in the world. The subject of brand names for electronics is a world of interesting trivia on its own but I digress.

This particular 34cm RCA model R14GG8RA employed a Thomson TX807 chassis and had died in a severe electric thunderstorm. Being at the lower priced end of the market, it was debatable whether or not it was worth repairing. However, the owner didn't have insurance and was also badly hit with other appliances failing in the storm, so a replacement wasn't on the agenda.

I removed the back to find that the main fuse (FP01) had blown and that the chopper FET (TP20) was short circuit.

Having repaired a few Thomson chassis before, I hoped it would be similar to earlier designs such as the ICC7, TX805 or TX92 but unfortunately it wasn't close enough. I checked all the active components within the power supply and replaced PNP transistors TP25 and TP23 and NPN transistor TP22. Zeners diodes DP27 and DP21, as well as diodes DP25 and DP26, were also changed, though I wasn't too sure of the value of DP27 (I assumed 27V).

I also found that resistor RP20 was open and that RP21 was dodgy, so these were replaced, as was optocoupler IP01.

After all this major surgery, I felt it was time to switch on. Of course, one is always apprehensive at this stage because one mistake can force you to start all over again but with even more collateral damage.

I switched it on and was relieved there was no explosion but was disappointed that nothing else happened. It was time to check the secondaries of the power supply. It was then that I noticed that RP90, which is a feed resistor to DP90 on the UA line, had burnt up.

Not having a circuit, I had no idea of the value of this resistor but from its discoloured bands it looked like a 2.2Ω unit, which I fitted. I switched it on again and found I now had UB = 106V and UA = 5.6V, which seemed reasonable although the set was still dead. On the plus side, the standby LED (DK01) was on and there was 106V on the collector of the line output transistor and 5V on the collector of the line driver transistor. However, there was no line drive and none of the controls on either the remote or the TV itself worked.

It was time to delve deeper. I measured 5V to the microprocessor (IR01) and EEPROM (IR02), as well as to the infrared receiver IK01. However, there seemed to be no output from the remote control receiver.

I checked the remote control with a tester to find it wasn't working either but that turned out to be just a flat battery. When I tried it again with the TV set, I could now see some life

coming out of the remote control receiver and being fed to the microcontroller.

By now I had managed to get a copy of the circuit diagram from a colleague but unfortunately there was extremely little detail as to what the voltages should be – nor were there any waveforms on the circuit.

Switch-on sequence

Next, I tried working out how this set was meant to switch on and guessed that the STANDBY voltage from the microprocessor (IR01-20) switched TR08 and TR07 to power up the jungle IC (IC01 – TDA8842). And although it looked like signals were getting to the microcontroller, none were coming out. This problem sometimes happens in Philips TVs and is due to a faulty EEPROM. The one in this set is an ST24W04 (IR02), so I tried an EEPROM from another set and even tried it without any IC, but it made no difference.

I felt I had come about as far as I could without help so I decided to contact Australian Technical Support (ATS) who are the agents for this set. I faxed them with a combined request for price and availability for the parts I suspected, plus help with the symptoms. I got a response from their Spare Parts department the same day (how's that for service) and placed an order for the EEPROM, the microcontroller and remote receiver.

The very next day I got a response from Technical Support at ATS, with the following explanation:

"For the set to come on, pin 2 of IR01 = 0V and pin 20 = 5V. It appears UA is low and hence V_{DD} on IR01 might not be high enough and not operate properly. UA on Standby should be at least 9V. Check RP90 = 0.22 ohms. Check TL03. Fax us back if you still have a problem".

Well, if you remember, I had fitted a 2.2Ω resistor for RP90, which is 10 times the value it should be. However, I was slightly sceptical about this being the cause of the fault, as the circuit shows one of the few marked voltages for pin 42 V_{DD} of IR01 (TMP47P1637VN) as 5.5V, which is only 0.5V more than I was getting.

Anyway, I didn't have any better ideas so I fitted a 0.22Ω resistor in place of the 2.2Ω resistor and was delighted to find that it fixed absolutely everything! The set now worked perfectly –ATS were spot on.

As a matter of course, I did check TL03 as advised but it was OK. The parts I had ordered – but were now unnecessary (though I expect they will be useful one day in the future) – arrived the next day. From go to whoa it was a total of three days – I wish more companies would respond as quickly and helpfully as this.

The set is indeed unusual and complex, using sophisticated new ideas in power supplies. Mark Paul in "Television" magazine (UK) has recently described the circuit techniques employed. The chopper power supply is described as "Free-Oscillating Safe Intelligent" (FROSIN) and is basically a self-oscillating (25kHz-100kHz) flyback converter type whose operating frequency depends on the mains input voltage and the load.

It also features a "digital burst" mode for standby operation, which reduces the power consumption from 45W to less than 2W. In addition, the MOSFET chopper (TP20) employs zero-voltage switching (ZVS) to ensure minimum turn-on loss and interference.

It's all very clever and high tech. **SC**

End of Financial Year Special

Robotics & Mechatronics CD
Build and simulate robotic and electromechanical systems. The CD Rom deals with all aspects of robotics control systems, transducers, motors/actuators and circuits. Uses images, video clips and animations/simulations. Case studies include NASA Mars Rover, Milford Spider and the Furby as practical examples.
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Includes "MultiSim2001" Circuit Simulator and "UltiBoard2001" PCB Layout Student Versions for one price! The most powerful general purpose circuit design tool in the world with the latest in PCB layout tools. Widely used in Australian TAFEs & Universities.
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A complete learning resource for this difficult branch of electronics. Sections include Analog Fundamentals, Transistors, Op-amps, Filters & Oscillators. Incorporates SPICE simulator with 50 editable circuits and test quizzes.
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A complete learning resource covering the principles and practice of digital electronics. From binary and hexadecimal up to an introduction to microprocessor based systems. Includes worksheets and quizzes.
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A sound introduction to the principles and application of the most common electronic components and how they form complete circuits. Includes colour photographs, full audio commentary, animations, virtual laboratories and quizzes.
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End of Financial Year Special

PRODUCT SHOWCASE

No more dead mobiles!

Ever been caught out with a dead mobile phone battery . . . and a perfectly good notebook computer sitting beside you?

Never again: Targus Australia has released a mobile phone charger which plugs into your notebook or laptop's USB port, completely in the background and without affecting the computer's performance.

No drivers are required – the USB port is energised when the computer is on.

That means your mobile can be topped up whenever you have access to your computer.

Another innovation is the complementary 9V-to-USB adaptor, providing emergency power through a standard 9V alkaline battery. Up to 30 minutes talk-time is available, depending on the mobile phone model.

Contact:
Targus Australia
Ph: (02) 9807 1222
website: www.targus.com.au

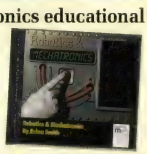
A & AB-type Mini USB Connectors

Not something you need every day but if you do, Kycon now offers the mini A-type and AB-type USB connectors in addition to the B-type.

They're intended for such applications as digital cameras, MP3 players and PDAs.

Contact:
Kycon Inc (Ca, USA)
Ph: 0011 1 408 494 0330
www.kycon.com

Emona's Robotics & Mechatronics educational CD



A new education CD from Emona Instruments will be of interest to anyone wanting to know more about the exciting field of robotics and mechatronics.

The CD-ROM, deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them.

It is designed to enable students (and anyone else!) with little previous experience of electronics to design and build electromechanical systems. Full case study material including the NASA Mars Rover, the Milford Spider and Furby) is used to show how practical robotic systems are designed.

The CD (originally from Matrix Multimedia of the UK) sells for $129 in the student version, $299 in the single user version or $595 in 10-user site licence (all including GST).

Contact:
Emona Instruments Pty Ltd
PO Box 15 Camperdown NSW 1450
Ph: (02) 9519 3933 Fax (02) 9550 1378
website: www.emona.com.au

100kHz-2GHz hand-held RF FS analyser

The world's first wide bandwidth, hand-held field RF strength analyser has just been released by Kenelec Scientific.

The 700g MIT-3201 is ideal for use in the field. It has user friendly, menu-driven controls for intuitive operation.

160 channel levels can be displayed simultaneously on the liquid crystal display and up to 1600 different frequencies with channel names can be logged, recalled, edited and exported.

With metering down to 100kHz, it is suitable for low power work in the AM broadcast band. Similarly, newer, low power RF transmitters on the market such as wireless computer peripherals and remote controls can be readily tested.

The MIT3201 can uncover exotic transmitters used as bugs, including 900MHz wireless video cameras and small FM transmitters.

Typical uses for the MIT3201 are the testing, installation and maintenance of mobile telecommunications systems, CB radio antenna installation and service along with satellite television receivers. Sources of RF interference from devices such as light dimmers can also be efficiently diagnosed.

In addition to the MIT 3201 field strength analyser, Kenelec has also released an RF power meter, digital LCR meter, spectrum analyser, plus an arbitrary and function generator.

Contact:
Kenelec Scientific Pty Ltd
23 Redland Dve, Mitcham Vic 3132
Ph: (03) 9873 1022
website: www.kenelec.com.au

Home Theatre Package from Altronics

If you have the space, Altronics can turn your viewing room into a mini home theatre with their new home theatre package.

It has 4 surround-sound satellite speakers, a centre channel speaker and a 150w-powered sub. The compact size of these speakers means thatwill your lounge room needs no longer to be be cluttered up with huge bulky equipment. The satellite speakers measure just 110w x 130h x 130d. The specifications are even more impressive. With rated power of 15W, (maximum power 30W) and frequency response at 110Hz-20KHz means that these speakers pack a punch.

The specifications of the 150W-powered amplifier are impressive for its price and size. Amplifier rated power (0.1% THD) is 120W, frequency response at 40-160Hz and input impedance is50KΩ.

The system has a recommended retail price of $599.00 and is available from Altronics store, mail order or their dealers.

Contact:
Altronics Distributors Pty Ltd
Ph: 1300 797 007
website: www.altronics.com.au

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Here's a good case for a new computer . . .

Dick Smith Electronics have released a new computer case that is ideal for computer upgrades or for those who want to build their own PC.

The A-Open mid-tower case has a 250W power supply and is designed for high expansion capacity, with seven slots and six drive bays. It also has "bend-in" edges for safe assembly and installation. No screws are required for assembly: the case features a smart 'slide-in' bracket.

The Aopen computer case (Cat XH6904) has a recommended retail price of $88.00 and is available from all Dick Smith Electronics stores, Dick Smith PowerHouse stores and also via mail order (Direct Link 1300 366 644) or via visiting the DSE website.

Contact:
Dick Smith Electronics
Ph: (02) 9642 9100 Fax: (02) 9642 9153
website: www.dse.com.au

Tech-Rentals 2002 catalog now available

Tech-Rentals, the largest rental company of its type in the Southern Hemisphere, has announced the release of its 2002 catalog.

It contains technical information and application tips on the vast array of test & measurement instruments, business equipment, chemical analysis tools, scientific research instruments, medical equipment and communication devices available from Tech-Rentals.

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Premier Batteries' IQ PAC: a very clever battery charger/analyser

Charging batteries in portable equipment is often a hit-and-miss affair. Do you charge after each use? Do you wait until the batteries are flat, to avoid memory effect? Or perhaps somewhere in between? And how do your choices affect the life of the battery?

A new charger from Premier Batteries will go a long way to answering all of these questions – and maintaining your battery in tip-top condition, extending its life.

The IQ PAC not only charges – automatically – it analyses the battery condition at the same time. It won't overcharge or overheat your battery – both of which will dramatically reduce battery life.

With three charging rates, three discharge rates and constant current or pulse charging, it suits a wide range of battery capacities and types. And speaking of types, there are adaptor plates to suit most common batteries and many uncommon ones too, whether they are for handheld radios, phones, notebook/laptop computers, power tools and many other appliances. It suits Nicad, NiMH and Li-Ion batteries.

There are four ways to maintain your battery:

- "Charge" charges your battery.
- "Quick Analyze" analyses and conditions while charging your battery so you know how it will perform in less time.
- "Spec Analyze" tests your battery to specification standards for warranty returns.
- Follow a "Quick Analyze" with a "Spec Analyze" if your battery doesn't show full capacity to completely condition your battery!

The IQ PAC has an inbuilt LCD screen to show you what's happening with your battery. It's mains powered and weighs less than 1kg. A 16-page instruction manual explains how to program the unit and how to analyse various types of batteries.

For more information, contact the Australian distributors, Premier Batteries.

Contact:
Premier Batteries Pty Ltd
P.O. Box 149 Moorebank NSW 1875
Ph: (02) 9755 1845 Fax: (02) 9755 1345
website: www.premierbatteries.com.au

ScopeMeter has up to 7 times faster screen update

The Fluke 190C (colour screen) ScopeMeter now offers faster screen updates than the previous Fluke 190 series. The main benefit this faster update gives users is the capability of seeing dynamic behavior instantaneously, useful for instance when making adjustments to a system under test.

The new Digital Persistence mode helps to find anomalies and to analyse complex dynamic signals by showing the waveforms amplitude distribution over time using multiple intensity levels and user selectable decay time.

Contact:
Fluke Australia
Ph: (02) 8850 3333 Fax: (02) 8850 3300
website: www.fluke.com

Infrared Link with Printing Software

Microgram Computers were unable to find an IrDA printer adapter at a realistic price. So instead they sourced a USB-to-infrared adapter with bundled software which achieves the same result. All you do is connect to the USB port of your computer and then point your PDA or notebook to the adapter to print your documents.

The Infrared Link to USB Connection with Printer Software operates under Win 98, ME and 2000 and has a recommended retail price of $139.00.

Contact:
Microgram Computers
Unit 1/14 Bon Mace Cl, Berkeley Vale NSW 2261
Ph: (02) 4389 8444 Fax: (02) 4389 8388
website: microgram.com.au

New DIN rail switch-mode power supply

Electus Distribution has released a new range of compact, lightweight industrial DIN rail switch-mode supplies that feature full temperature, voltage and current overload protection. The power supplies have a built-in EMI filter, a power-on LED and operate from 85-264VAC at 47-440Hz. Input and output connections are via a 7.5mm pitch terminal block.

Two models are available, with outputs of either 12V DC @ 3.5A (MP-3190) $129.95; or 24VDC @2.0Amps (MP-3192) $129.95.

Contact:
Electus Distribution
PO Box 6424, Silverwater NSW 2128
Ph: (02) 9741 8552 Fax: (02) 9741 8500
website: electusdistribution.com.au

Jaycar ELECTRONICS

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This saves you up to 20%.

*The $700 and $1200 figures are after the discount has been applied. IE goods total before discount would be around $800 and $1350. Goods included in the deal are: cameras, lenses, power supplies, processors, monitors, brackets and cables.

A time lapse VCR, digital video recorder and our 16 channel multiplexer can be added to the deal!

5 in 1 USB Card Reader / Writer + 2 Port USB Hub

This USB 5 in 1 card reader is a high performance device designed for accessing data from Compact flash cards, IBM micro drive, Secure digital card(SD), Multimedia cards(MMC) and Smart media cards. Connects via USB port on both MAC or PC and also features a 2 port USB hub.
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Too many parking tickets?
This simple to use timer will count down from up to 19hrs and 59mins. Beeping loudly when time is up. Supplied with keyring. Also ideal for cooking or sporting events.
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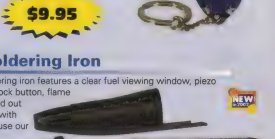
Piezo Gas Soldering Iron

This easy to use gas soldering iron features a clear fuel viewing window, piezo auto ignition switch, fuel lock button, flame adjustment control and fold out soldering stand. Supplied with 1.0mm tip. Gas required, use our Cat. NA-1020 $5.95.



Spare 1.0mm
Tip Cat. TS-1105 **$2.95**
Spare catalyst Cat. TS-1104 **$12.95**

Gas Soldering Iron Cat. TS-1100

$59.95

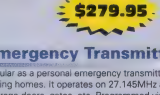
2 Way CCFL Torch

A new concept in torches, this non slip rubber gripped weatherproof torch uses a xenon globe that provides up to 200% more light than a standard globe, the beam can be adjusted to spot or flood while a CCFL (cold cathode fluoro lamp) in the handle provides a flood of light for up to 12hrs. Supplied with 4 AA batteries and lanyard.
Cat. ST-3078

$24.95

USB Video Grabber

Use this USB video grabber to capture video images and store them for later use or view them across your network. The software can be configured to detect movement in certain zones of the camera image and advise you via phone or email when the motion is detected. Supports 320 x 240 @ 30fps
Cat. QV-3054



$279.95

Replacement Garage Door Remote

Commonly used on many garage door openers and electric gates that operate on 27.145MHz. The controller is custom coded via a DIP switch under the battery cover. 9V battery required.Use Cat SB-2423 $4.95
Cat. LR-8827

$59.95

Pendant Style Emergency Transmitter

This unit is popular as a personal emergency transmitter (PET) as used in nursing homes. It operates on 27.145MHz and can also operate garage doors, gates, etc. Programmed via a DIP switch & is powered by a LR-44 battery.
Use our SB-2516 $1.40.
Cat. LR-8828

$54.95

Jaycar Electronics opening soon in Geelong

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3,6,9,12V 200MA Solar Charger

NEW

This is a portable battery charger that's ideal for people on the move who can't always access mains power to charge things like their mobile phone, digital camera, PDA, camcorder, electric razor, personal stereo, etc. The panel conveniently folds away like a book for storage, and features a detachable flylead that offers four common DC power plugs for charging. The panel will also accept 4 x AAA rechargeable batteries for recharging and, once charged, these batteries can also double as an emergency power source. A charge rate of approximately 200mA/hr can be achieved in good sunlight. Unfolded, the unit measures 354(W) x 230(H) x 15(D)mm and approx. 170(W)mm when folded-up. Great for camping!
Cat. MB-3590

$59.95

5W 12V Plastic Frame Solar Panel

NEW

Mounting a solar panel doesn't get much easier. The tough plastic frame surrounding the amorphous solar cell features removable, recessed bolts that can be replaced with mounting screws to fasten the panel to a suitable mounting surface, saving the need for brackets. Measures 500 x 345 x 15mm and is supplied with double insulated 2-metre long flylead with heavy duty alligator clips.
Cat. ZM-9040

$99.95

Briefcase Solar Panel

NEW

The briefcase design, once opened, two large 448 x 298mm panels are revealed, together with charge adaptor lead, alligator clips and a cigarette lighter socket. In full sunlight, the panels will deliver a charge rate of approximately 750mAH at 14V - great for emergency charging of a car or boat battery as well as lead acid batteries. Two extendable supports enable the charger's panels to be directed towards the sun more efficiently. Unfolded the unit measures 770mm(lw) and folded together, 380(lw) x 525(h) x 35(d)mm
Cat. MB-3592

$229

400W Isolated Inverter 12VDC-230VAC 50HZ

This mid sized unit will cater for most common electrical products. Isolated for increased safety. Use for larger items such as 20" TV's, 100 watt halogen worklights, electric fans etc. perfect for camping trips.
Cat. MI-5064
WAS $199.50

SAVE $30

NOW $169.50

Garrison Latching Remote Control Switch

This simple latching switch is ideal for activating home alarms, garage doors/gates etc or use for in car switching applications. 12v required.
•2 transmitter supplied. Extra transmitters Cat LR-8821 $30.50ea
See cat P158 for full details.
Cat. LR-8820 **WAS $99**

SAVE $20

NOW $79

EQUATOR Economy Alarm

NEW

If you're contemplating an alarm for your vehicle but can't justify all the bells and whistles offered by our more advanced Equator alarms, then this entry level Equator should satisfy. Even though we've dubbed this alarm an economy model, it is still feature-packed and will provide thorough protection to any vehicle.
Features include instant triggering, Immobiliser, Door lock/unlock, Flashing LED, Passive arming, Trigger memory report, and the list goes on.
WHAT YOU GET •Electronic black box controller •2 transmitter key-fob learning remote controls •Shock sensor •Boot pin switch •Mini size siren •Ignition cut-out relay •Wiring looms
SPARE REMOTE: Cat. LA-8986 $34.95

Cat. LA-8985

$119.50

Steering Wheel Car Alarm

NEW

This completely wireless alarm requires no installation and mounts onto your steering wheel to sense a breaking window or even a sharp jolt to your vehicle. Flashing LEDs alert thieves there is an alarm and, if triggered, the built-in flashing strobe light and the 130dB siren will complete the annoyance. Features include a high-low sensitivity setting, adjustable re-entry timing and key activated arm and disarm switch. A low battery LED indicator is also included. 2 x AA alkaline (use Cat. SB-2424 $2.75pk 2) and 1 x 9V alkaline (use Cat. SB-2423 $4.95ea) batteries required - not included.
Cat. LA-8965

$39.95

Carguard Immobiliser

NEW

Economical protection for cars. This silent security device features an IR arm/disarm remote control, 8 digit programmable security code, dashboard warning LED, "whisper piezo buzzer and dash mounting infrared receiver.
Supplied with wiring, mounting hardware, warning stickers, instructions and 1 remote control.
•Extra remotes Cat. LA-8992 $18.95.
Cat. LA-8920

$59.95

Rechargable Spotlight 500,000 Candle Power

NEW

Inbuilt SLA battery provides up to 60 minutes of operation. The battery can be charged via your car cigarette lighter or by the supplied mains plug pack. The lock on trigger provides hands free operation. Ideal for fishing! Beware of inferior quality units.
Cat. ST-3310

$29.95

Jaycar ELECTRONICS

OVERNIGHT DELIVERY AVAILABLE

Front Facing Input / Output for Computers

This board transfers the USB, fire-wire, audio line in/out and RS-232 ports to the front of your computer for easy access. Simply mounts in the 3.5" drive slot and is supplied with all leads and mounting hardware to complete the job.
Was $99.95 Cat. XC-5170

NOW $89.95 SAVE $10

Mini 4 Port USB Hub

This tiny hub is small enough to take anywhere and supports both full speed (12Mbps) and low speed (1.5Mbps). The hub also supports both Open Host Controller Interface (OHCI) and Universal Host Controller Interface (UHCI). 47(L) x 33(W) x 21(D) and is MAC and PC compatible. Cat. XC-4815

$35

USB to USB PC Link Cable

Transferring data between computers has never been easier. Plug this transfer cable into both machines' USB ports and enjoy tremendous transfer speed (6MB/s), complete with handy plug n' play support. 100cm in length x 2, main unit measures 52(L) x 28(W) x 10(H). Cat. XC-4840

$59.95

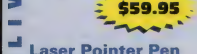
USB to USB PC Link Networking Cable

A low cost solution for PC to PC networking via USB ports, eliminating the need for individual network cards. Maximum transfer rate is 5MB, supports up to 17 PC's via a networking hub, supports TCP/IP/NetBEUI/IPX/SPX protocols plus full NDIS driver implementation. Size is same as our XC-4840. Cat. XC-4845

$69.95

Laser Pointer Pen with Mobile Phone Alert

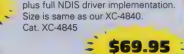
Providing a more discrete way of answering your mobile in meetings, this pen features 4 LED's that flash when your mobile phone rings, a 1mw laser pointer is built into the top of the pen making it the ultimate accessory, and it can writes also. Cat. ST-3091



$24.95

Vibro Pen

Designed to alleviate aches and pains, this pen is in a class all by itself with its vibrating head. Simply press the head onto pressure points of the body for the desired effect. Instructions and pressure point chart included. Cat. ST-3096



$24.95

Samsung Digital Voice Recorder

This incredible digital voice recorder from SAMSUNG® will store up to 810 minutes (Yes! That's 13.5 hours) of voice quality audio in a neat & slim, hand-held unit. 4 separate message groups are available and each group can have up to 100 messages. An integrated LCD shows the status of various functions. The recorder has a VOX function and variable microphone sensitivity for voice operated recording. Software is included to enable messages to be downloaded to a PC and e-mailed to friends or colleagues. Cat. XC-0280
WAS $419

NOW $379 SAVE $40

NEW BOOKS FOR 2002

Build Your Own Audio Valve Amplifiers

Transistors rule supreme in today's HI-FI world, but valves are still popular with many. This book gives you a brief history of valves and teaches you the principles on which valve amps are constructed, including projects for preamplifiers, power amplifiers, and Hi Fi amplifiers.
Soft cover 151 x 224mm, 252pages
Cat. BM-2483

$39.95

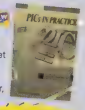
IC Timers Guidebook

This book demonstrates the theory of how various timers work. This is done by way of an introduction to resistor-capacitor circuits, and in depth chapters on TTL & CMOS digital IC timers, the LM-555 and other IC devices, op amp timer circuits, retriggerable timers and long duration timers. Part 2 of this book presents a variety of different circuits and projects, some standalone and some are for incorporation into other circuits. Soft cover 181 x 235mm, 240 pages. Cat. BM-2480

$29.95

PICs in Practice

PICs in Practice is an introduction to the PIC16C5x family of microcontrollers and provides a functional introduction to the chip and its architecture as well as examples of power-on reset and oscillator circuits. Sample software applications are also included to illustrate various tasks that PICs can be applied to. These include a magnetic stripe card reader, phone card reader, LCD display driver and touch memory read/write. A useful and interesting book. Soft cover 150 x 230 mm, 252 pages. Cat. BM-2478



$36.95

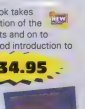
Guide to Picmicro® Microcontrollers

PIC micros have become very popular and this book takes the reader on a journey from the physical description of the device to the design of a number of useful projects and on to discussions on software and programming. A good introduction to PICs. Soft Cover 185 x 237, 312 pages
Cat. BM-2481

$34.95

Telephone Projects

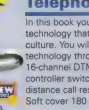
In this book you will discover the history of telephone technology that has become an indispensable part of our culture. You will learn the fundamentals of telephone technology through some hands on projects including: 16-channel DTMF controller, electronic bell, automatic tape controller switch, hands free headset telephone, long distance call restrictor, 300-baud modem and more. Soft cover 180 x 230mm, 204 pages. Cat. BM-2479



$34.95

Electronic Projects for the 21st Century

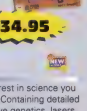
If you are an electronics hobbyist with an interest in science you will find this an essential book for your library. Containing detailed instructions to perform experiments that involve genetics, lasers, holography, alternative energy sources and more. Projects you can build include: lie detector, Geiger counter, expansion cloud detector, air pollution monitor, ELF monitor, pinhole camera, plus much more.Soft cover 180 x 230mm, 256 pages. Cat. BM-2484



$34.95

Designing Audio Circuits

How does speech, music, or any sound get from the record, CD or tape to the loudspeaker?
This book introduces you to the different types of audio circuits and how they work, plus tips on circuit construction and fault finding. Component layouts and parts lists allow you to make any of the circuits contained in this book. Soft cover 154 x 226mm, 276 pages.
Cat. BM-2482



$34.95

GIVE A GIFT VOUCHER

THE EASY WAY TO SHOP!

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Jaycar ELECTRONICS

END OF FINANCIAL YEAR SPECIALS

OVERNIGHT DELIVERY AVAILABLE

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goot Soldering Station

JAPANESE MADE

Our new soldering station is a precision, Japanese manufactured instrument with excellent temperature stability and anti-static characteristics. The unit's lightweight soldering pencil has a grounded tip and is fitted with a comfortable silicon rubber grip. The controller is has a digital temperature display and includes a calibration control. This is a high quality soldering station and is one of the best we have seen. 230 - 240VAC-supply voltage, 24VAC output voltage, 65 watt Capacity heater, and 200 - 480°C temperature range.

Spare tips TS-1441 0.5mm
TS-1442 0.2mm / $16.50 ea
Soldering Station Cat. TS-1440

$269.95 NEW

BUY THIS MONTH AND RECEIVE A FREE 1KG ROLL OF SOLDER WORTH $28.95
Choose from our Cat. NS-3002 0.71mm or Cat. NS-3015 1.0mm.

Anti-static Wrist Strap

Cat. TH-1780
WAS $11.25

SAVE $3

NOW $8.25

Delux Adjustable Punch Down Tool

The professionals choice. Supplied with "88" punch down blade.
Cat. TH-1740
WAS $78.95

$59.95

SAVE $19

Spare Blades to Suit
88 BLADE Cat. TH-1742 **$21**
110 KRONE BLADE Cat. TH-1743 **$21**

Wire Stripper and Cutters

Simple single action auto adjusting stripper. A must have for the toolbox!
Cat. TH-1824
WAS $19.95

SAVE $5

NOW $14.95

Supercrimp Tool-Ergonomic

Professional ratchet crimper with large handles for greater leverage. And the adaptability to change crimping dies to suit your needs quickly and easily. Cat. TH-1950
WAS $69.95

SAVE $10

NOW $59.95

DIES TO SUIT

TH-1951	Die - 4P4C Telephone Connectors	**$24.50**
TH-1962	Die - 6P6C Telephone Connectors	**$24.50**
TH-1953	Die - 8P8C Computer Network Connectors	**$24.50**
TH-1954	Die - Fully Insulated Crimp Terminals	**$21.95**
TH-1955	Die - BNC/TNC Coax Connectors for RG58/59/62	**$21.95**
TH-1956	Die - F- type CATV to suit RG59 / RG6	**$24.50**
TH-1957	Die Insulated Crimp Terminals 22 - 12 AWG	**$24.50**

6P/8P Modular Crimping Tool

Cat. TH-1935
WAS $59.95

SAVE $10

NOW $49.95

Heavy Duty QC Insulated Terminal Crimper

The professional way to crimp QC terminals and lugs quickly and easily.
Cat. TH-1829
WAS $49.95

SAVE $10

NOW $39.95

100 Power Driver Bit Set

Comes with just about every imaginable type of screwdriver bit!!
Cat. TD-2038
WAS $29.95

SAVE $10

NOW $19.95

Vulkan Kit Solder Set

SAVE $15

NOW $74.95

- Gas iron
- Up to 120W heating power.
- European built quality

Cat. TS-1260
WAS $89.95

Auto Range DMM

Our best value auto range DMM features capacitance, frequency, diode test, data hold, relative measurement function, 10amp, auto power off and includes a protective rubber holster. Cat. QM-1535

$39.95

Low Cost DMM

One for the tool box or beginner. 19 range, 10 amp, transistor test, diode test, 3.5 digit display, plug in leads.
Cat. QM-1500

$14.95

Jaycar 25W Pro Iron 240V

- 410° regulated temperature
- Tips to suit: 1mm TS1552 $8.95ea
  1.6mm TS1553 $8.95ea

Cat. TS-1550
WAS $34.95

SAVE $5

NOW $29.95

PC Board Holder

Cat. TH-1982
WAS $10.95

SAVE $3

NOW $7.95

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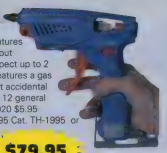
Butane Hot Glue Gun

This durable ABS constructed glue gun operates using standard butane gas and features a built in piezo lighting mechanism and foldout stand for safe cooling after use. You can expect up to 2 hours continual use for each refill of gas. Features a gas control thumbwheel and gas lock to prevent accidental gas loss. Supplied in plastic carry case with 12 general purpose glue sticks. Use our gas Cat. NA-1020 $5.95
Extra glue sticks are available: Pkt 6 for $2.95 Cat. TH-1995 or Pkt 50 for $14.95 Cat. TH-1996.



Hot Glue Gun Cat. TH-1998

NEW

$79.95

12VDC Soldering Fume Extractor

NEW

This fan features an activated carbon filter that's designed to absorb flux and lead fumes. Two rear air deflectors are included - one angled, the other a straight air exit where a 100mm O.D. diameter pipe can be connected and lead to a window or similar exit point. Three filters are supplied.
•Powered by 12VDC 450mA plug pack adaptor (not included) - use our MP-3006 $17.50
•Unit measures 220(W) x 270(H) x 168(D)mm.
Cat. TS-1580

$139

goot 240V 13 Watt Soldering Pencil

This Goot soldering pencil is perfectly balanced and features a soft rubber grip and highly flexible silicone sheathed lead. Supplied with a fine 0.2mm tip suitable for SMD or light PCB work and includes a two-metre long mains cord.
Spare Replacement Tips
Cat. TS-1447 0.5mm $16.95
Cat. TS-1448 0.2mm $16.95

NEW

$59.95

Japanese made

Cat. TS-1446

Piezo Ignition Micro Torch

Ideal for brazing, silver soldering, jewellery work, heat-shrinking, plumbing and general hobby work. Features adjustable flame and up to 1300deg C flame
Cat. TS-1660.

$39.95

Buy this month and receive a free can of gas worth $5.95
Cat. NA-1020

Lab Bench Magnifier Lamp

NEW

Offers 3 dioptre magnification, 22 watt fluorescent illumination, a protective cover flap over the 115mm lens and horizontal and vertical steel arms to give you adjustment in all directions.
240v powered.
Cat. QM-3527

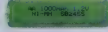
$119

BATTERY BARGAINS

Stock up and save!

AAA 650mAH Ni-MH
was $3.59ea **NOW $3.15ea**
BUY 10 $2.75ea Cat. SB-2444

AA 1000mAH Ni-MH
was $3.35ea **NOW $2.95ea**
BUY 10 $2.60ea Cat. SB-2455



AA 1650mAH Ni-MH
Nipple: was $4.50ea NOW $3.95ea
BUY 10 $3.60ea Cat. SB-1700
Solder: was $4.75ea NOW $4.15ea
BUY 10 $3.75ea Cat. SB-1702

Digital Clamp Meter AC/DC

Make quick and easy measurements of current in both AC and DC amps to a 3% accuracy. Features data hold, zero function, capacitance, frequency, auto range, auto power off, and voltage too.
•For the full list of features see page 188 of the 2002 catalogue.
Cat. QM-1562
WAS $159

NOW $139

SAVE $20

10MW Laser Diode + Collimating Lens

10mW laser diode component, red in colour and supplied with 7mm dia collimating lens.
The collimating lens keeps the laser diode beam focused to a narrow point.
Note: Static sensitive
•Threshold Current: 30mA
•Operating Voltage: 45mA
•Optical Power: 10mW
•LD Reverse Voltage: 2V
•PD Reverse Voltage: 10V
•Size: TO-18 (5.6mm dia)
Cat. ZD-1954

$19.95

Blacklight Spot 75W 240V

Create glowing effects at parties using this black spotlight available in both BC fitting and Edison screw fitting.
ES TYPE Cat. SL-2761
BC TYPE Cat. SL-2763
WERE $14.95ea

NOW $9.95ea

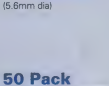
SAVE $5

Motorola 2N3906 Transistor 50 Pack

Limited quantities available.

•Very similar to BC558
•TO92 case •PnP •VCB=40V
•Ic=200mA •hFE=100(typ)
Cat. ZT-2171

$3.95



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Doorstop Alarm

NEW

Designed similar to a door stop, this will emit a deafening screech of 118dB when a door is opened against it, allowing you to alarm closed or a partially open door. Ideal for office situations or for your bedroom door while you sleep. Requires one 9V alkaline battery - not included, use our SB2423. Measures 35(D) x 45(W) x 41(H)mm.
Cat. LA-5012

$19.95

4 Channel Colour Quad Processor

This unit will accept up to 4 camera inputs and display them sequentially on a monitor screen or show all 4 channels simultaneously on a single split screen. Other features include independent adjustment of colour, contrast and brightness for each input channel, twin video outputs to drive both a monitor and VCR. Video connections are via BNC and a mains plugpack is supplied.
Cat. QC-3363

$449

Colour Dome Camera

Protect your home with this colour dome camera. This camera features 330 TV lines resolution, adjustable focus and composite video output.
Requires 12vdc regulated power supply, use Cat. MP-3011 $24.95.
Cat. QC-3484
WAS $239

SAVE $20

NOW $219

6" B&W Security Monitor - New Model

NEW

Ideal for small surveillance installations this monitor features a built in switcher for 2 cameras. The switching time can be adjusted between 2 to 20 seconds. 2 x 12VDC outputs are provided to power cameras or other low-current consumption devices. Includes A/V RCA inputs and outputs. Includes mains plugpack.
Cat. QM-3401

$129.50

Mini CMOS B&W Pinhole Camera with Audio

This tiny CCD camera is perfect for covert surveillance. Pinhole lens can be adjusted for focal length. Complete with microphone. Requires 9VDC power.
Cat. QC-3458
WAS $69.95

SAVE $10

$59.95

Super Bright Blue LED Keyring Torch

Emits a super bright ice blue light that is visible over a long distance. Ideal for finding a keyhole at night or create dazzling effects when dancing.
Cat. ST-3047
WERE $14.95ea

SAVE $9.90

NOW 2 for $20

Keyring Personal Alarm

NEW

The piezo screamer emits an unbearable 120dB screech that is sure to scare off even the most persistent thief. Also includes a small flashlight to aid finding a key lock after dark. Supplied with a strong key ring chain and battery. Measures 66 x 40 x 20mm.
Cat. LA-5185

$11.95

Wireless Remote Control Extender

This device will extend the transmitting range of any IR controlled devices in your home or office, ideal if you want to control your TV or VCR from another room. supplied with 2 x 240Vplugpacks.
Cat. AR-1805
WAS $89.95

SAVE $15

NOW $74.95

1.25A Regulated Switchmode 3-12V DC Plug Pack

Slide voltage selector is on wall side of housing so that setting can not be changed accidentally.
- Supplied with 7 plugs.
- Size: 60 x 95 x 57mm
- Safety approval Number: N16687.

Cat. MP-3031
WAS $45

SAVE $6

NOW $39

2.4GHZ A/V Sender with Remote Extender

A powerful 10mW signal enables you to enjoy crystal clear reception of cable TV in a room away from the cable TV set top box! You can even use your cable TV remote control in another room as this unit includes a wireless repeater! Each unit comes complete with stereo audio and video transmitter and receiver, including AC power pack supplies. A special 6-way DIP switch is included to avoid interference with other units. Can also be used with VCR's, DVD, VCD, and CD players.
Cat. AR-1806 **WAS $239**

SAVE $40

NOW $199

Extra Reciever Cat. AR-1807 **WAS $129 NOW $109.50 SAVE $19.50**

Laser 74Min/650Mb CD-R 15Pk

Cat. XC-4708

NEW

$11.95

6 Way Mains Filter with Phone Filter

Protect valuable HI-FI and computer equipment from the destructive effects of power surges, added phone connection offers protection your telephone or modem line too.

Cat. MS-4036
WAS $39.95

SAVE $10

NOW $29.95

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Jaycar ELECTRONICS

NEW CAR SOUND FROM JAYCAR

RESPONSE

XL SUBWOOFERS

These awesome woofers are stacked with features and represent outstanding value for money. Features include: • Polypropylene cones • 1" wide rubber surrounds for high excursion for greater output • Cast hammer finish frame • Dual 8 ohm voice coils. • Double magnets • Chrome washer and back plate • Perimeter venting for increased voice coil cooling • Heavy duty push terminals

10" Sub Woofer

Specifications

- •Nominal impedance: 4 Ohms (both 8 ohm coils in parallel)
- •Power Handling: 200 Watts RMS
- •Sensitivity: SPL - 1Watt @ 1 metre: 87.31
- •Resonant Frequency (Fs): 24.38Hz
- •Total Q Factor (Qts): 0.299
- •Equivalent Volume (Vas): 73.19 Lt
- •Xmax: 10.5mm

Typical application
Vented box: •Box volume: 30Lt
Cat. CS-2270

$169

12" Sub Woofer

Specifications

- •Nominal impedance: 4 Ohms (both 8 ohm coils in parallel)
- •Power Handling: 200 Watts RMS
- •Sensitivity: SPL - 1Watt @ 1 metre: 88.17
- •Resonant Frequency (Fs): 25.58Hz
- •Total Q Factor (Qts): 0.409
- •Equivalent Volume (Vas): 93.42 Lt
- •Xmax: 10.5mm

Typical application
Vented box: •Box volume: 79.95Lt
Sealed box: •Box volume: 31Lt
Cat. CS-2272

$199

RESPONSE

TITANIUM FINISH SUBWOOFERS

These stunning new speakers feature unique titanium coloured cones and baskets which look very classy indeed. Featuring inverted dustcaps, titanium look polycones, deep-bumped back plate and 1" surround for extra high cone excursion without bottoming out. Value Plus!

10" Sub Woofer

Specifications

- •Nominal impedance: 4 Ohms
- •Power Handling: 125 Watts RMS
- •Sensitivity: SPL-1W@ 1 88.17
- •Resonant Frequency (Fs): 33.298Hz
- •Total Q Factor (Qts): 0.502
- •Equivalent Volume (Vas): 29.55 litres
- •Xmax: 9mm

Typical application
Vented box: •Box volume: 48lt
Cat. CS -2274

$99

12" Sub Woofer

- •Nominal impedance: 4 Ohms
- •Power Handling: 150 Watts RMS
- •Sensitivity SPL-1W@ 1: 87.26
- •Resonant Frequency (Fs): 35.5Hz
- •Total Q Factor (Qts): 0.636
- •Equivalent Volume (Vas): 51.01 litres
- •Xmax: 9mm

Typical application
Sealed Box Size:
•Box volume: 36.6 Lt
Cat. CS-2276

$129

130WRMS 12V Car Amplifier Module

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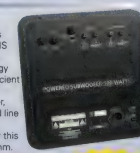

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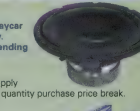

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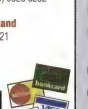

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'Matchless' Metal Locator

Want to find a fortune? Buried treasure, perhaps? Lost coins on the beach? Or perhaps you fancy earning some pocket money finding other people's valuables. Either way, this project should really interest you. It's an el-cheapo induction-balance (IB) metal locator that delivers surprisingly good performance.

By Thomas Scarborough

An induction balance (IB) metal locator has a good depth of penetration and distinguishes well between ferrous and non-ferrous metals. It is also capable, to a large extent, of rejecting iron and also tin foil. This is a boon for anyone who is searching for coins or noble metals.

My aim with this design was to create a 'minimalist' device – one that would work well but without all the bells and whistles of the expensive, commercial designs. I found that it was possible, with just a handful of components, to design a high-quality metal locator.

For instance, on comparison with the first-class EE-Magenta Buccaneer, this design delivers 95% of the performance in the category where it really matters – a clear indication of the presence of metal.

Simple, but it works

An IB metal locator is usually far more complex than the design shown here – the EE-Magenta Buccaneer, for example, uses more than 70 components. This one uses less than 20.

The reason for the simplicity is that I have dispensed with analog circuitry, and instead used a digital transmitter and receiver.

As the search coils pass over metal, only digital signals of a certain amplitude break through to a peak detector (IC1b). Since these are in the audio range, they are immediately transferred to the piezo sounder or headphones.

On testing the sensitivity of this design in air, with optimal tuning and using a 25mm-diameter brass coin, it gave a clear signal at 150mm, and a 'screaming' signal at 110mm. It was also able to detect a pin at 30mm.

Note that these figures may not apply in the ground, where depth of penetration will depend largely on the mineralisation present.

In contrast, the locator is far more reluctant to pick up tin foil. A tin foil disk of the same size as the brass coin was only detected at half the distance in air. This rejection of tin foil is due in part to the metal locator's low frequency, which avoids what is called skin effect.

Besides this, if the two coils are positioned as described, ferrous metals (iron) are, to a very large extent, rejected – to such an extent, in fact, that a 25mm diameter brass coin weighing seven grams looks the same to the metal locator as a lump of iron weighing 20 times as much. Large non-ferrous objects are detected at half a metre distance and more.

The locator's power consumption is conveniently low. It draws around 10mA, which means that it may be powered off a small 9V battery. If an alkaline battery is used, this will provide about 48 hours' continuous use. In my experience, the number of coins that are found on a beach in an hour or two should easily make up for the cost of batteries!

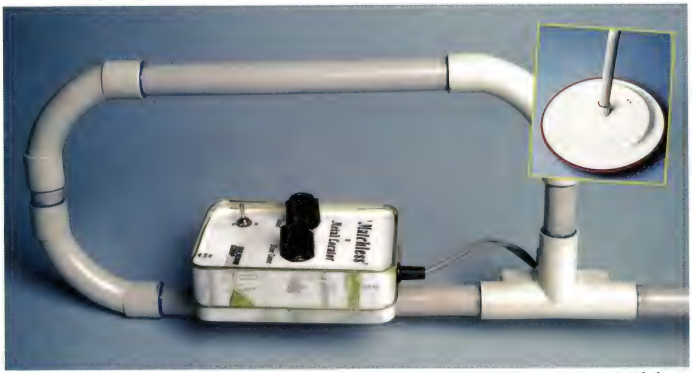
Finally, while the *stability* of the locator is not the best, it's by no means the worst either. Re-tuning is necessary from time to time, especially in the first few minutes of use. One soon becomes accustomed to giving the Fine Tune knob an occasional tweak – perhaps with every 40 or 50 sweeps of the search head.

Circuit description

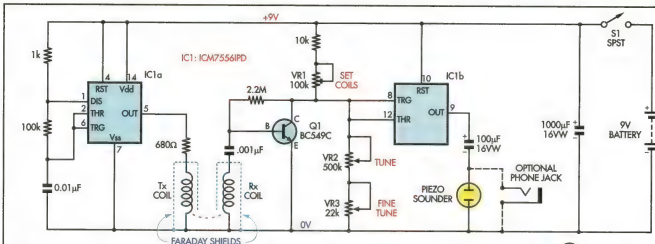
The search head of a typical IB metal locator contains two coils: a transmitter (Tx) coil and receiver (Rx) coil.

In this case, the Tx coil is driven by a square wave oscillator, which sets up an alternating magnetic field in the coil. The Rx coil is then positioned in such a way that it partly overlaps the Tx coil. By adjusting the amount of overlap, a point can be found where the voltages in the Rx coil 'null' or cancel out, so that little or no electrical output is produced. A metal object which enters the field then causes an imbalance, resulting in a signal.

The transmitter (IC1a) is a standard 555 oscillator configuration, using one half of the ICM7556IPD dual low power CMOS version of this IC.



The two "business ends" of the metal detector: the electronics box at the top end, mounted on 20mm PVC pipe, with the inset showing the search coils at the bottom end, potted and mounted in plastic dinner plates.



SC 'MATCHLESS' METAL LOCATOR

Fig.1: the circuit is based on a dual 555 timer (CMOS version) and a pair of hand-wound search coils. No amplifier is provided – the output from one of the timers drives either a piezo sounder or a pair of headphones.

Do NOT use the veteran NE556N IC, by the way.

IC1a oscillates at about 700Hz, determined by R/C components around pins 1, 2 and 6. The 680Ω resistor limits the current passing through the Tx coil.

The receiver section (IC1b) is preceded by a simple yet sensitive preamplifier stage, based on Q1, which amplifies the signal received from the Rx coil. This is fed directly to IC1b, which is used here as a high-performance sine-square convertor. Its input at pins 8 and 12 is biased by the divider formed by the 10kΩ resistor and pots VR1-VR3, so that only pulses of a certain amplitude break through to output pin 9.

There is a point at which, with careful adjustment, the signal is just breaking through in the form of a crackling sound. When the locator's output is adjusted to a fast crackle, the presence of metal turns this into a 'scream'. This is heard from the piezo sounder or through standard headphones. The 7556 IC allows up to 100mA of output current, therefore no further amplification is required.

Winding the coils

The one drawback to any IB metal locator design is its need for two coils, which must be very carefully and rigidly positioned in relation to one another. Sometimes there's no room even for a fraction-of-a-millimetre error in positioning these coils. While this particular design makes things easier than usual, the placement of the coils will still require some patience. On the other hand, the winding of the coils is relatively easy. Each coil also includes a electrostatic (Faraday) shield, which helps to minimise ground effect.

The winding of the (identical) coils is not critical and a little give and take is permissible.

I used 30SWG (0.315mm) enamelled copper wire, winding 70 turns on a circular former, 120mm in diameter.

I created the former with a sheet of stiff cardboard with 12 pins stuck through it at a suitable angle (the heads facing slightly outwards). The coil was wound clockwise around the pins,

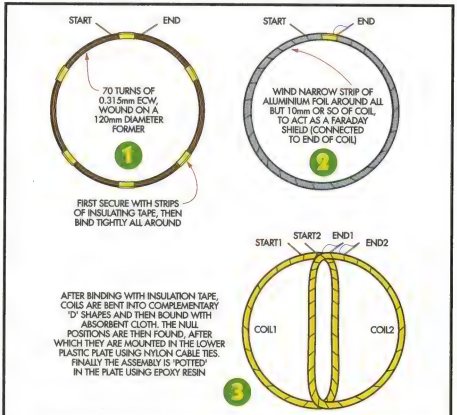


Fig.2: here's how to wind the two (identical) coils, which are assembled into a plastic dinner plate and then potted with epoxy to hold them rigid.

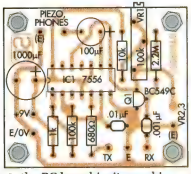


Fig.3: the PC board isn't very big – and there's not much on it!

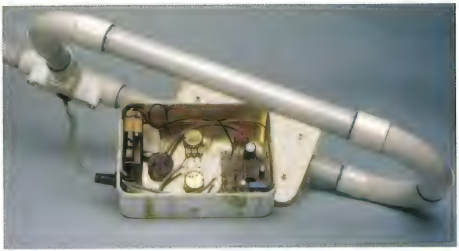
then temporarily held together with stubs of insulating tape passed under the coil and pressed together over the top. The coil may be jumble-wound (that is, you don't have to wind the turns on side-by-side in neat layers).

Once this has been done, the pins are removed, and a second coil is wound in the same way. In each case, mark the beginning and end wires. Each coil is then tightly bound by winding insulating tape around its entire circumference.

Now we add a Faraday shield to each coil. This is accomplished with some long, thin strips of aluminium foil. First scrape the enamel off each coil's end wire. Solder a 100mm length of bare wire to the winding wire, and twist this around the coil, over the insulating tape. This provides electrical contact for the Faraday shield.

Beginning at the base of this lead,

This photo clearly shows the potted search coils in situ.



Use this photograph with the component overlay at left and the wiring diagram below to help locate the various bits in their box.

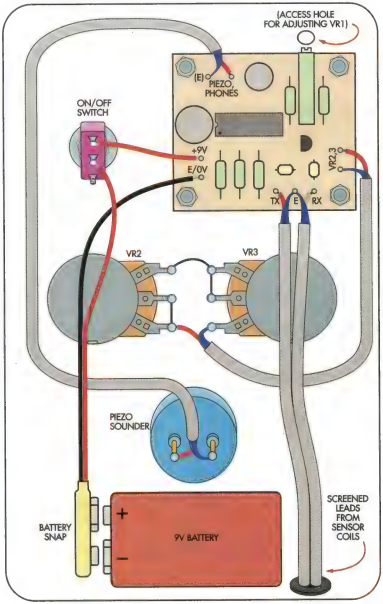


Fig.4: apart from the coils, it's all assembled in a lolly tin (fair dinkum!). Don't forget to eat the contents first.

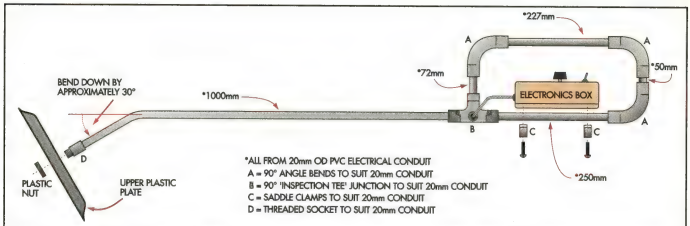


Fig.5: the assembly is a "sparkie's special", being constructed almost entirely from 20mm PVC electrical conduit and appropriate fittings. The exceptions are the box holding the electronics and the two plates surrounding the search coils.

the foil is wound around the circumference of the coil, so that no insulating tape is still visible under the foil – but the foil should not complete a full 360°. Leave a small gap (say 10mm) so that the end of the foil does not meet the start after having gone most of the way around. Do this with both coils. Each coil is now again tightly bound with insulating tape around its entire circumference.

Attach each of the coils to its own length of quality single-core screened audio cable, with the Faraday shield in each case being soldered to the screen. Do not use stereo or twin-core microphone wire to run both leads together; this may cause interference between the coils.

Gently bend the completed coils until each one is reasonably flat and circular, with each end wire facing away from you, and to the right of the beginning wire. Now bend them further until they form lopsided ovals — like capital Ds (see Fig.2). The backs of the Ds overlap each other slightly in the centre of the search head. This is the critical part of the operation, which we shall complete after having constructed the circuit.

Last of all, wind strips of absorbent cloth around each coil (I used strips of thin dishwashing cloth such as Chux), using a little all-purpose glue to keep them in place. Later, when epoxy resin is poured over the coils, this cloth meshes the coils into the resin.

Another view looking into the electronics box, this time from the other side up, or "ander kant bo" as they would say in Afrikaans.

Construction

The PC board of the Matchless Metal Locator measures 48mm x 42mm, and is coded 04106021. There are not many components, so it should be easy to assemble the board using the PC board overlay diagram in Fig.3.

With the exception of the CMOS IC, component values and types are not critical. The one critical component is the ICM7556IPD CMOS IC. I also tried the TS556CN IC in this position – it worked, but not as well.

Begin board assembly by soldering the nine terminal pins, the 14-pin dual-in-line socket for IC1 and the resistors. Continue with the capacitors, diodes and Q1.

Once soldering is complete, care-

Parts List – Matchless Metal Locator

1 PC board, code 04106021, 48 x 42mm
1 9V battery, preferably alkaline
1 9V battery snap lead
1 Piezo sounder
1 Metal case to suit, approx 130 x 90 x 40mm
2 Rigid plastic dinner plates
1 3.5mm chassis mount mono jack socket (optional)
1 14-pin DIL IC socket (optional)
4 M2.5 10mm bolts
8 M2.5 nuts
1 Rubber grommet
1 Large front-panel knob
1 Small front-panel knob
9 1mm diameter PC solder pins
1 On-off switch for mounting in circular hole
30SWG (0.315mm) enamelled copper wire
Nylon cable ties
Dishwasher cloth cut to 20mm strips (eg, "Chux")
Aluminium or tin foil cut to 20mm strips
PVC piping, joints, nuts and bolts as required (see Fig.3)

Semiconductors

1 ICM7556IPD dual CMOS timer IC (no substitutes)
1 BC549C bipolar transistor or close equivalent

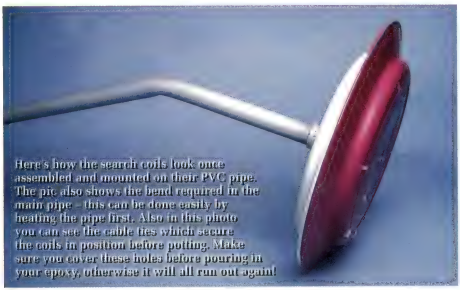
Capacitors

1 1000µF 16VW PC electrolytic
1 100µF 16VW PC electrolytic
1 0.01µF disc ceramic (code 10n or 103)
1 .001µF polystyrene (code 1n or 102)

Resistors (0.25W 5%)

	(4-band)		(5-band)
1	2.2MΩ		
1	100kΩ		
1	10kΩ	OR	
1	1kΩ		
1	680Ω		

1 100kΩ multiturn cermet trimmer (VR1)
1 470kΩ linear carbon pot (VR2)
1 22kΩ linear carbon pot (VR3)



Here's how the search coils look once assembled and mounted on their PVC pipe. The pic. also shows the bend required in the main pipe – this can be done easily by heating the pipe first. Also in this photo you can see the cable ties which secure the coils in position before potting. Make sure you cover these holes before pouring in your epoxy, otherwise it will all run out again!

fully check the board for any solder bridges, then use some short lengths of quality screened microphone wire to attach the piezo sounder, VR2 and VR3, with the screen (or braid) always being wired to 0V. If you wish, add a socket for headphones in parallel with or in place of the piezo sounder. Use insulated hookup wire to attach the battery and switch S1, keeping the leads short. Finally, attach the screened cables from the coils, with the screen again going to 0V, and insert IC1 in the DIL socket. Note that IC1 is static sensitive, and requires careful handling (discharge your body to earth before handling).

Fig.5 shows the suggested hardware construction, using PVC piping and joints. Bend the base of the metal locator's shaft under very hot water to obtain the angle shown. Alternatively, a swivel joint may be made.

The entire electronics (apart from the search coils) is mounted in a metal case, ensuring that no part of the underside of the PC board is touching the case. The adjustment slot for VR1 should be accessible via a small hole in the case. Mount VR2 and VR3 where quick and easy adjustment is possible.

A metal case is essential, otherwise the circuit is affected by electrostatic coupling (or capacitive effects). The metal case is connected to 0V, through the tab on the copper side of the PC board.

I was unable to obtain a purpose-made metal case in my city (Cape Town) but found that good quality metal sweet tins were readily available, so I used one of these. They are also considerably cheaper than similarly sized electronics enclosures and of course you get the sweets as well!

Setting the coils

A completed PC board is needed

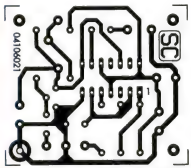


Fig.6: same-size PC board artwork in case you want to etch-your-own!

before we can 'pot' the coils. These are potted with epoxy resin in a hard plastic dinner plate, the sort you'd find in a picnic set. Any plastic plate of suitable size will do, on condition that it is rigid.

(A tip: don't pinch them from the family picnic set . . .)

First place the coils on top of one another – ensuring that they are correctly orientated, with each end wire facing away from you, and to the right of the beginning wire. Adjust both VR2 and VR3 to their midpoint. Adjust VR1 to about 90kΩ. Then attach a 9V battery and switch on. The circuit will most likely be screaming; that is, beeping loudly and continuously.

Now slowly move the coils apart. When they are somewhere past the halfway point, the headphones will fall silent. This is where the voltages in the Rx coil 'null'. Continue to move the coils apart. At a precise point – just before the coils no longer overlap at all – the headphones will begin to scream again (there may or may not be a low-level beep just before this).

It is at this precise point, and not a fraction of a millimetre either way, that the coils need to be set.

Take an indelible marker pen and mark out holes in the lower plate around both coils. These holes are used to pass cable ties through, to hold the coils tightly to the plate. Also use a cable tie to hold the audio cables to the plate. Use some Blu-tak (or Prestik) to tightly seal the holes underneath the plate before pouring in the resin – epoxy resin can be very 'runny' and sticks faster than many glues.

Also at this point carefully bend the coils at the centre of the plate until you reach the exact balance at which there is neither silence nor screaming in the piezo sounder/headphones, but just a crackle. A little drift should not matter at this point.

Now you are ready to mix and pour the resin. Use a modest amount of catalyst, so that there will be not too much heat and shrinkage in the resin. Pour the resin over the cloth which surrounds the coils, so as to soak it, and keep on pouring at least until the entire bottom of the plate is covered with resin.

This photo gives you a better idea of how the electronics box is mounted to the main PVC pipe. Ordinary saddle clamps hold it in place.

The circuit may no longer function correctly at this point until the resin has hardened, so make no more adjustments at this stage, but switch the circuit off and leave it for 24 hours or so.

I potted two sets of coils (that is, two complete search heads). The first worked perfectly, precisely as I had set it in the plate. The second contracted slightly as the resin set, so that no settings of VR2 or VR3 would produce a tone in the headphones. However, this is where the design of the Matchless Metal Locator shows its flexibility. By turning VR1 clockwise, the circuit was again functioning normally when VR2 and VR3 were set to their midpoint.

How to use it

Keep the search head away from all metal – and "noisy" computer equipment – and switch on. Adjust potentiometers VR2 (Tune) and VR3 (Fine Tune) to their mid-points. Then adjust VR1 with a screwdriver or plastic alignment tool until the metal locator is just at the point where a crackle is heard, between silence and a scream (or between a low-level hum and a scream). Use the tune and fine-tune knobs for any further tuning.

A fast crackling sound produces the best results. Move a coin over the search head and the piezo sounder should scream.

In actual use, the adjustment of the metal locator will be affected by the mineralisation of the ground you are searching, as well as temperature and voltage variations. So as mentioned earlier, readjustments to VR3 and VR2 are inevitable from time to time.

That's really all there is to it. In case of any problems, though, the author may be contacted at scarboro@iafrica.com. **SC**

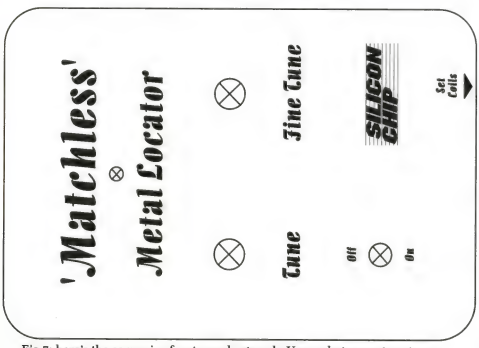


Fig.7: here's the same-size front panel artwork. Use a photocopy to act as a template when drilling the case.

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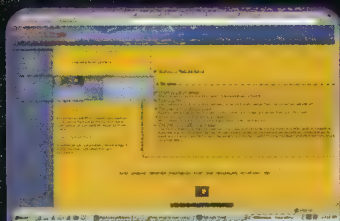

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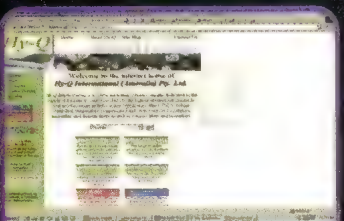

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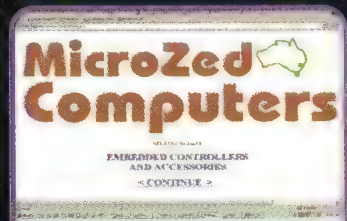

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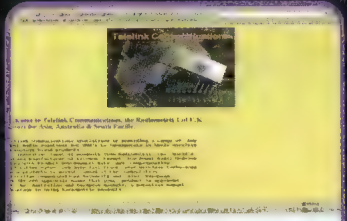

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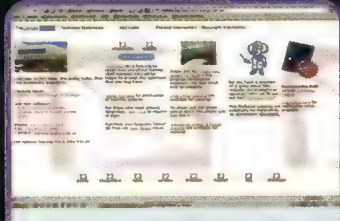

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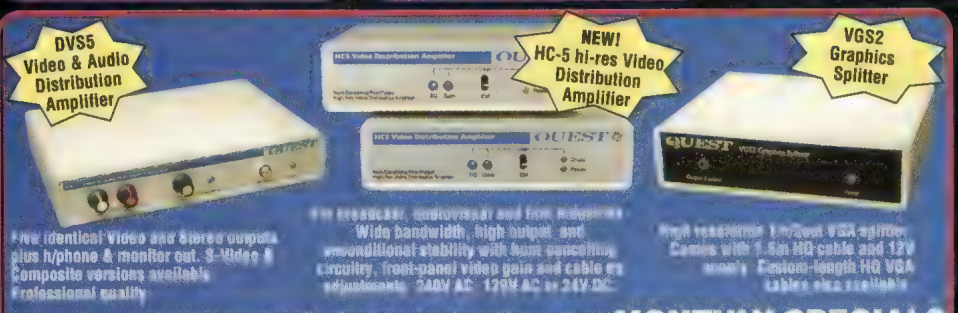

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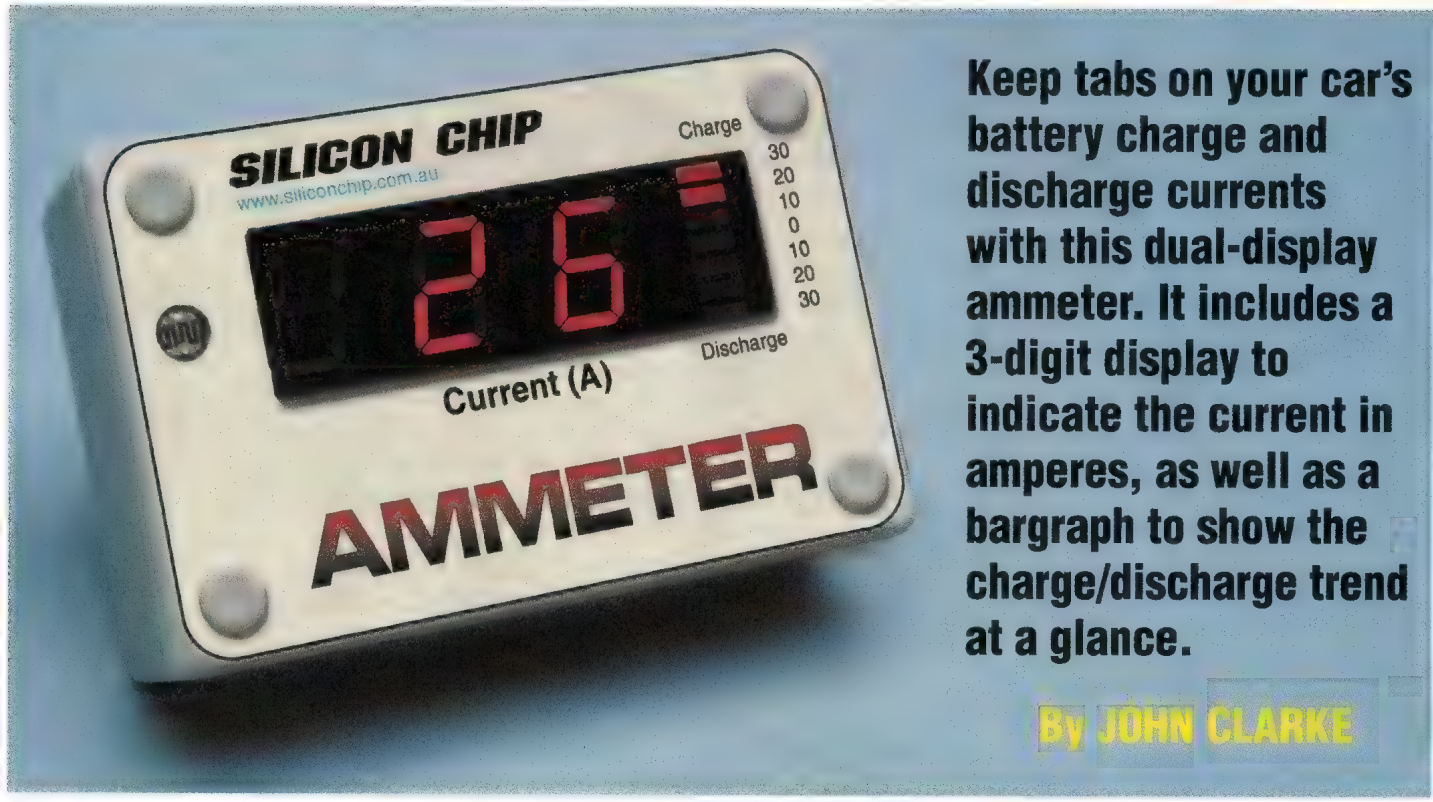


Keep tabs on your car's battery charge and discharge currents with this dual-display ammeter. It includes a 3-digit display to indicate the current in amperes, as well as a bargraph to show the charge/discharge trend at a glance.

By JOHN CLARKE

Compact 0-80A automotive ammeter

IT'S NOW RARE TO SEE an ammeter installed in a car. Instead, virtually all modern (and not so modern) cars have an "idiot" light to indicate battery charging. Normally, this light is off when the engine is running and only comes on if the alternator fails; ie, when no charge is being delivered.

Apart from that, it doesn't provide any other information during normal driving.

This means that when the light is out, you have no idea how much current is going into the battery or is being pulled out. And even when an ammeter was fitted, it was hardly what you would call a precision instrument. Most only gave a very rough idea of what happening.

However, if you are an enthusiast, you will want to know more about battery charge and discharge rates. This Automotive Ammeter can provide this information with a high degree of accuracy.

Why is it important?

Knowing the charging state of the battery is important since it's a major component of the cars' electrical system. If the battery isn't charging properly, you could be left stranded.

When the engine is running, the alternator normally provides all the power for the electrical loads and keeps the battery topped up. However, if there is insufficient charging current, the battery will gradually discharge. This can typically occur if the electrical load is high while the engine is idling, or if the connections to the battery are faulty or the battery itself is on the way out.

Measuring the battery current involves measuring the current flowing in all the leads to one of the battery's terminals. In addition, it's necessary to determine the direction of the current, so that we know whether the battery is being charged or discharged.

MAIN FEATURES

- Compact size
- Includes 7-LED bargraph display plus 2-digit readout
- ±0-30A indication on bargraph in 5A steps
- 1A resolution on 2-digit display
- Typical 80A maximum reading
- Dual indication for charge and discharge
- Automatic display dimming in low light conditions

Hall effect sensor

The SILICON CHIP Automotive Am-

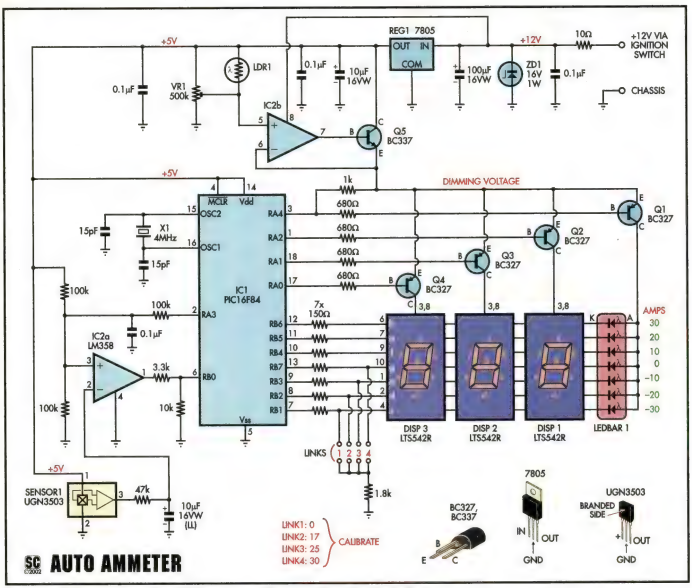


Fig.1: the PIC microcontroller (IC1) processes the signal from the Hall effect sensor (Sensor 1) and drives the 7-segment LED displays and the LED bargraph. LDR1, VR1 & IC2b automatically vary the display brightness according to the ambient light conditions.

meter measures the battery current using a Hall effect sensor. This monitors the magnetic field produced by current flow in the battery leads.

Fig.2 shows the sensor details. A ferrite core is placed around the battery leads, with the Hall sensor positioned in the air-gap. The leads from the battery produce a magnetic flux when ever current flows and this is induced into the ferrite core. This magnetic flux then passes through the sensor, which in turn produces a voltage that's proportional to the current in the leads.

What's more, the output of the Hall effect device goes positive for one direction of current and negative for the other. So the same sensor can determine both the magnitude of the current and its direction.

Main features

The SILICON CHIP Automotive Ammeter is housed in a small plastic case and matches the style of our previous PIC-based automotive projects. As before, the readout uses LED displays set behind a Perspex window in the lid. In this unit, there are three 7-segment LED displays and one bargraph display. The 7-segment displays show the current, with the lefthand digit showing a minus sign when the battery is being discharged.

The vertical LED bargraph on the righthand side of the front panel consists of seven LEDs and operates in dot mode. The centre LED indicates zero amps (0A) while the three LEDs above this progressively light in 10A-steps for currents of 10-19A, 20-29A and 30A and above.

The bargraph resolution is increased somewhat by making it possible for more than one LED come on at a time. Thus, the 0A and 10A LEDs both light for currents from 5-9A; the 10A and 20A LEDs both light for currents from 15-19A; and the 20A and 30A LEDs both light for currents from 25-29A.

The three LEDs below the 0A LED indicate the discharge current and operate in exactly the same manner – but in the opposite direction.

As with our previous instruments, we've included automatic dimming and this varies the display brightness according to the ambient light level. That way, the displays are nice and bright for daytime viewing but are

Parts List

1 microcontroller PC board, code, 05106021, 78 x 50mm
1 display PC board, code, 05106022, 78 x 50mm
1 Hall Effect PC board, code 05106023, 20 x 12mm
1 front panel label, 80 x 53mm
1 plastic case utility case, 83 x 54 x 30mm
1 Perspex or Acrylic transparent red sheet, 56 x 20 x 3mm
2 plastic spacers, 1.5mm thick (12 x 7mm)
1 Ferrite core suppressor for 12.5mm cables (DSE D-5375, Jaycar LF-1290 or similar)
1 4MHz parallel resonant crystal (X1)
1 LDR (Jaycar RD-3480 or equivalent)
8 PC stakes
3 7-way pin head launchers
1 5-way 2.54mm DIL jumper launcher
1 jumper shunt (2.54mm spacing)
2 DIP-14 low cost IC sockets with wiper contacts (cut for 3 x 7-way single in-line sockets)
1 9mm long x 3mm ID untapped brass spacer
1 6mm long x 3mm ID untapped brass spacer
2 6mm long Nylon M3 tapped spacers
2 M3 x 6mm countersunk screws
2 Nylon M3 washers (1mm thick) or 1 Nylon M3 nut (2mm thick)
2 M3 x 15mm brass screws
4 150mm cable ties
1 2m length of red automotive wire
1 2m length of black or green automotive wire (ground wire)
1 2m length of 2-core screened cable
1 500kΩ horizontal trimpot (code 504) (VR1)

Semiconductors

1 PIC16F84P microcontroller with AMMETER.HEX program (IC1)
1 LM358 dual op amp (IC2)
1 UGN3503 linear Hall Effect sensor (SENSOR1)
1 7805 5V 1A 3-terminal regulator (REG1)
4 BC327 PNP transistors (Q1-Q4)
1 BC337 NPN transistor (Q5)
3 HDSP5301, LTS542R common anode 7-segment LED displays (DISP1-DISP3)
1 10-LED red vertical bargraph (Jaycar Cat. ZD-1704 or equiv.)
1 16V 1W zener diode (ZD1)

Capacitors

1 100μF16VW PC electrolytic
1 10μF low leakage (LL) 16VW PC electrolytic or tantalum
1 10μF 16VW PC electrolytic
3 0.1μF MKT polyester
2 15pF ceramic

Resistors (0.25W 1%)

3 100kΩ	1 1kΩ
1 47kΩ	4 680Ω
1 10kΩ	7 150Ω
1 3.3kΩ	1 10Ω 1W
1 1.8kΩ	

Calibration parts (optional)

1 8m length of 0.25mm diameter enamelled copper wire
1 56Ω 5W resistor
1 3.9Ω 5W resistor

Miscellaneous

Automotive connectors, automotive cable, neutral cure Silicone sealant, heatshrink tubing, cable ties, etc.

turned down at night so that they don't become distracting. The degree of display dimming is adjustable with a trimpot.

The accompanying panel shows the other features of the unit. In particular, the maximum reading is 80A and the resolution is 1A. If the current goes above 80A, the unit overloads and displays "OL" on the middle and left 7-segment readouts.

Best of all, you don't need to be a rocket-scientist to use it, as there are no controls to operate. It's turned on and off with the ignition and you just read the displays. Simple!

Circuit details

As already indicated, the circuit is based on a PIC microcontroller which minimises both the cost and the parts count. In fact, the circuit is similar to our previous PIC-based automotive projects. It's the bits that hang off the microcontroller and the embedded software that make it perform its intended role.

Refer now to Fig.1 for the circuit details. IC1 – a PIC16F84 microcontroller – forms the basis of the circuit. It accepts input signals from the sensor (Sensor 1) via comparator IC2a and drives the 7-segment LED displays and the LED bargraph.

Most of the circuit complexity is hidden inside the PIC microcontroller and its internal program. That's the beauty of using a microcontroller – we can easily do complicated (and not so complicated) things with very few parts.

A-D converter

Among other things, IC1 operates as an A/D (analog-to-digital) converter. In simple terms, this converts the analog voltage produced by the sensor to a digital value which is then used to drive the LED displays. Let's see how this works.

First of all, the DC signal output from the Hall sensor (pin 3) is fed to pin 2 of comparator stage IC2a via a filter consisting of a 47kΩ resistor and 10μF capacitor. This filter circuit removes any ripple voltage from the Hall sensor output.

The output from the Hall sensor is nominally at 2.5V when there is no magnetic field applied to it. At the same time, pin 3 of IC2a is biased to 2.5V using two series 100kΩ resistors across the 5V supply.

The associated 100kΩ resistor to RA3 of IC1 (pin 2) pulls IC2a's pin 3 input to 1.67V when RA3 is at ground or to 3.33V when RA3 is at 5V. However, if RA3 is repeatedly switched between +5V and ground at a fast rate, it follows that pin 3 of IC2a can be set to any voltage between 1.67V and 3.33V, depending on the duty cycle of the switching waveform.

In operation, the A/D converter uses IC1 to ensure that the voltage applied to pin 3 of IC2a matches the sensor output voltage applied to pin 2. It does this by producing a 1953Hz pulse width modulated (PWM) signal at its RA3 output, the duty cycle of which is continually adjusted to produce the required voltage on pin 3 of IC2a.

For example, if the duty cycle at RA3 is 50%, the average voltage output will be 2.5V. This is filtered by a 0.1μF capacitor and applied to pin 3. Other voltages are obtained by using

different duty cycles, as indicated above.

IC2a simply acts as a comparator. Its pin 1 output switches low or high, depending on whether the voltage on pin 2 is higher or lower than the voltage on pin 3. The output from IC2a is then fed to RB0 via a 3.3kΩ limiting resistor. This is included to limit the current flow from IC2a when its output goes high; ie to +12V. The internal clamp diodes at RB0 then limit this voltage to 0.6V above IC1's 5V supply (ie, to +5.6V).

Note the 10kΩ pulldown resistor on RB0. This ensures that the signal on RB0 is detected as a low when pin 1 of IC2a goes low.

The A-D conversion process uses a "successive approximation" technique to zero in on the correct value. This all takes place inside the microcontroller, with the duty cycle for each successive approximation (and thus the valued stored in an internal 8-bit register) controlled by the software.

Initially, RA3 operates with a 50% duty cycle and the internal register in IC1 is set to 10000000. IC1 then checks the output of comparator IC2a to see whether it is high or low. It then adjusts the duty cycle at RA3 by a set amount, updates the register and checks the output of IC2a again.

This process continues for eight cycles, each step successively adding or subtracting smaller amounts of voltage at pin 3 of IC2a. During this process, the lower bits in the 8-bit register are successively set to either a 1 or a 0 to obtain an 8-bit A-D conversion.

Following the conversion, the binary number stored in the 8-bit register is processed (we'll look at this in more detail shortly) and converted to a decimal value so that it can be shown on the 3-digit LED display. Once again, this takes place inside the PIC microcontroller.

Note that the possible range of values for the 8-bit register is from 00000000 (0) to 11111111 (255) – ie, 256 possible values. However, in practice we are limited to a range of about 19-231. That's because the software must have time for internal processing to produce the waveform at the RA3 output and to monitor the RB0 input.

Processing the register data

OK, let's now take a closer look at how the PIC microcontroller processes the data in the 8-bit register following conversion. To do this, it requires several items of information.

First, it needs to know the voltage produced by the Hall effect sensor when there is no current flow. This is nominally half the supply voltage (ie, 2.5V) but could be anywhere between 2.25V and 2.75V. This value is determined during the setting up procedure by installing Link 1 which pulls the RB1 line low via a 1.8kΩ resistor.

Second, the processor needs to know what the output voltage from the Hall effect sensor is for a known current. This is measured at either 17A, 25A or 30A by installing either Link 2, Link 3 or Link 4 on the RB2, RB3 and RB7 outputs.

The Hall effect device's quiescent output voltage is then subtracted from this measured value to derive a calibration number.

For example, let's say that the Hall effect sensor's output is 2.5V at 0A and 3.0V at 17A (ie, we are calibrating at 17A). In this case, the calibration factor would be 3 - 2.5 = 0.5 and this is stored by the processor along with the calibration amperage (17A in this case).

Once the processor knows this information it can calculate other currents, depending on the output from the Hall sensor. First, it subtracts the sensor's quiescent voltage from its new output voltage (note: this provides values that can be either positive or negative, depending on the current direction). The result is then multiplied by the calibration amperage and divided by the calibration factor to get the final result.

This is best illustrated by another example. Let's assume that the calibration factor is 0.5 and that the calibration amperage is 17A. Further, let's assume that the sensor output is at 3.4V. In this case, the current would be (3.4 - 2.5) x 17/0.5 or 30.6A.

This result (to the nearest amp) is shown on the LED displays and on the bargraph.

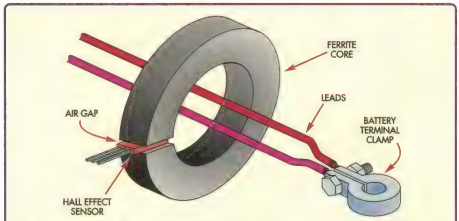


Fig.2: the current sensor consists of a ferrite core placed around the battery leads, with a Hall effect device positioned in the air-gap. A magnetic flux is induced in the ferrite when ever current flows through the leads and this flux passes through the Hall effect device which generates a proportional output voltage.

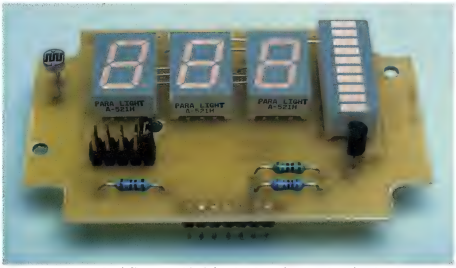
Driving the displays

The 7-segment display data from IC1 appears at outputs RB1-RB7. These directly drive the display segments via 150Ω current-limiting resistors, while the RA0, RA1, RA2 & RA4 outputs drive the individual displays in multiplex fashion via switching transistors Q1-Q4 (more on this shortly).

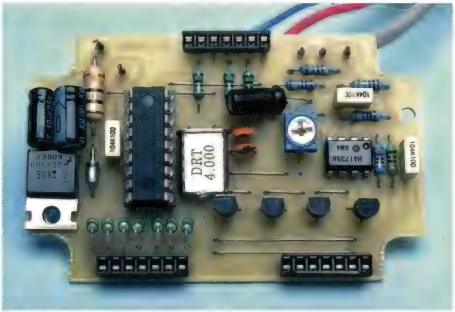
As shown, the corresponding display segments are all tied together, while the common anode terminals are driven by the switching transistors. Similarly, the cathodes of the LEDs in the bargraph display (LED-BAR1) are also connected to the display segments.

What happens is that IC1 switches its RA0, RA1, RA2 & RA4 lines low in sequence to control the switching transistors. For example, when RA0 goes low, transistor Q4 turns on and applies power to the common anode connection of DISP3. Any low outputs on RB1-RB7 will thus light the corresponding segments of that display.

After this display has been lit for a short time, RA0 is switched high and



This view shows the fully assembled display board. Note that the three 7-way pin headers are all mounted on the copper side of the board, with their leads just protruding through from the top.



The pin headers on the display board plug into matching in-line sockets on the microcontroller board. Note that the three electrolytic capacitors are mounted so that they lie horizontally across other components.

DISP3 turns off. The 7-segment display data on RB1-RB7 is then updated, after which RA1 is switched low to drive Q3 and display DISP2. RA2 is then switched low to drive DISP1 and finally, RA4 is switched low to give the LED bargraph its turn.

Note that IC1's RA4 output has a 1kΩ pullup resistor connected to the emitter supply rail for transistors Q1-Q4. This is necessary to ensure that Q1 switches off fully, since RA4 has an open-drain output.

Between driving DISP1 and the LED bargraph, the RB1-RB7 outputs are set as inputs. These have internal pullup resistors that hold them high unless pulled low via one of the links (ie, Links 1-4) and the associated 1.8kΩ resistor. By monitoring the state of these RB inputs, we can determine whether one of the links has been installed for calibration.

Link 1 tells the processor that the voltage from the Hall effect sensor is at the quiescent level (ie, when there is no current flow through the battery lead). The other three links set the current level used for calibration (you only have to choose one).

For example, if Link 2 is installed, the processor knows that the voltage output from the Hall sensor corresponds to a 17A current flow. Links 3 and 4 are respectively used for the alternative 25A and 30A current calibration levels.

Display dimming

Trimpot VR1, light dependent resistor LDR1 and op amp IC2b are used to control the display brightness. As shown, IC2b is wired as a voltage follower and drives buffer transistor Q5 to control the voltage applied to the

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	1	1.8kΩ	brown grey red brown	brown grey black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	4	680Ω	blue grey brown brown	blue grey black black brown
❑	7	150Ω	brown green brown brown	brown green black black brown
❑	1	10Ω	brown black black gold (5%)	not applicable

Table 2: Capacitor Codes		
Value	IEC Code	EIA Code
0.1µF	100n	104
15pF	15p	15

emitters if the display driver transistors (Q1-Q4).

When the ambient light is high, LDR1 has low resistance and so the voltage on pin 5 of IC2b is close to the +5V supply rail delivered by REG1. This means that the voltage on Q5's emitter will also be close to +5V and so the displays operate at full brightness.

As the ambient light falls, the LDR's resistance increases and so the voltage at pin 5 of IC2b falls. As a result, Q5's emitter voltage also falls and so the displays operate with reduced brightness.

At low light levels, the LDR's resistance is very high and the voltage on pin 5 of IC2b is set by VR1. This trimpot sets the minimum brightness level and is simply adjusted to give a comfortable display brightness at night.

Clock signals

Clock signals for IC1 are provided by an internal oscillator which operates in conjunction with 4MHz crystal X1 and two 15pF capacitors. The two capacitors are there to provide the correct loading for the crystal, to ensure that the oscillator starts reliably.

The crystal frequency is divided down internally to produce separate clock signals for the microcontroller and for display multiplexing.

Power supply

Power for the circuit is derived from the vehicle's battery via a fuse and the ignition switch. This is fed in via a 10Ω resistor and decoupled using 0.1µF and 100µF capacitors. Zener diode ZD1 provides transient protection by limiting any spike voltages to 16V. It also provides reverse polarity protection – if the leads are reversed, ZD1 conducts heavily and blows the 10Ω resistor.

The decoupled supply is fed to 3-terminal regulator REG1 to derive a +5V rail. This rail is then further filtered using 0.1µF and 10µF capacitors and applied to IC1, Sensor 1 and the collector of Q5. Op amp IC2 derives its power from the decoupled +12V rail.

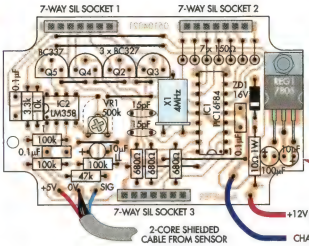


Fig.3 (left): install the parts on the microcontroller PC board as shown here.

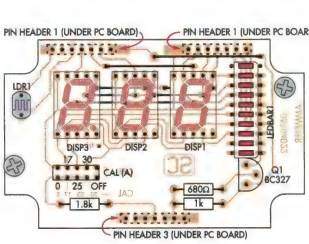


Fig.4: the parts layout on the sensor board is shown above, while at left is the display board.

Software

We don't have space to describe how the software works here but if you really must know, you'll find the source code posted on our website.

Of course, you really don't have to know how the software works to build this project. Instead, you just buy the preprogrammed PIC chip and plug it in, just like any other IC. So let's see how to put it all together.

Construction

Fig.3 shows the assembly details. Most of the work involves assembling three PC boards: a microcontroller board coded 05106021, a display board coded 05106022 and a sensor board coded 05106023. The latter carries just three parts: the Hall effect sensor (Sensor 1), a 0.1µF capacitor and three PC stakes and can be built in next to no time at all.

The assembled display and microcontroller boards are stacked together piggyback fashion using pin headers and cut down IC sockets to make all the interconnections. This completely eliminates the need to run wiring between the two boards.

Begin by inspecting the PC boards for shorts between tracks and for possible breaks and undrilled holes. Note that a "through-hole" is required on the display board to accommodate a screwdriver to adjust VR1 which mounts on the microcontroller board. This hole is just below the decimal point for DISP3 (see photo).

Note also that the two main boards need to have their corners removed, so that they clear the mounting pillars inside the case.

The sensor board can be assembled first. Install the capacitor and the three PC stakes first, then complete the assembly by mounting the Hall effect sensor. Mount the sensor with its leads at full length and be sure to mount it with the correct orientation.

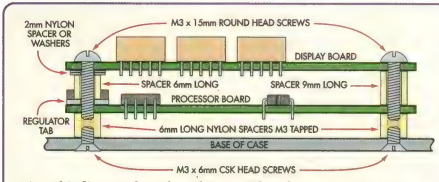
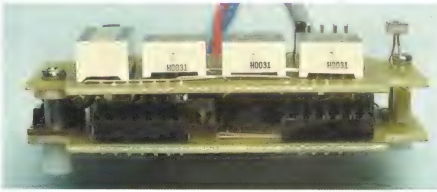


Fig.5: this diagram shows how the two PC boards are stacked together and secured to the bottom of the case using screws, nuts and spacers. Be sure to use nylon spacers and washers where specified.



This is the completed board assembly, ready for mounting in the case. The top of the LDR should be about 3mm above the displays.

The microcontroller board is next. Being by installing the nine wire links, then install the resistors. Table 1 lists the resistor colour codes but we recommend that you check each value using a digital multimeter, just to be sure.

Note that the seven 150Ω resistors at top right are mounted end-on.

Trimpot VR1 can go in next, followed by a socket to accept IC1 – make sure this is installed the right way around but don't install IC1 just yet. IC2 is soldered directly to the board – install this now, followed by zener diode ZD1 and transistors Q2-Q5.

Watch out here – Q5 is an NPN BC337 type, while Q2-Q4 are all PNP BC327s. Don't mix then up.

REG1 is mounted with its metal tab flat against the PC board and its leads bent at right angles to pass through their respective holes. Make sure that its tab lines up with the mounting hole in the PC board.

The capacitors can go in next but make sure that the electrolytics are mounted with the correct polarity. **Note that the 10µF capacitor below VR1 must be a low-leakage (LL) type.** It is installed so that its body lies horizontally across the adjacent 680Ω resistors. It's a good idea to bend its leads at rightangles using needle-nosed pliers before mounting the capacitor on the board.

Similarly, the two electrolytic capacitors below REG1 must be installed so that their bodies lie over the regulator's leads (see photo).

Crystal X1 mounts horizontally on the PC board and can go in either way around. It is secured by soldering a short length of tinned copper wire to one end of its case and to a PC pad immediately to the right of Q3.

Finally, you can complete the assembly of this board by fitting PC stakes to the external wiring points and installing the three 7-way in-line sockets. The latter are made by cutting down two 14-pin IC sockets into in-line strips. Use a sharp knife or a fine-toothed hacksaw for this job and clean up any rough edges with a file before installing them.

Before plugging in IC1, it's a good idea to check the supply rails on its socket. You don't need to have any other circuitry connected to the microcontroller board to do this – just connect a 12V supply to the board and check that there is +5V on pins 4 & 14 of the socket.

If this is correct, disconnect power and install IC1 in its socket, making sure that it is oriented correctly.

Display board assembly

Now for the display board. Install the eight wire links first (note: six of these mount under the displays), then install the three 7-segment LED displays. Make sure that these are properly seated and that their decimal points are at bottom right before soldering them

The LED bargraph can go in next – this mounts with the corner chamfer at bottom right (ie, labelled side towards the edge of the PC board). This done, install LDR1 so that its top face is about 3mm above the displays.

The remaining parts, including the 5-way DIL pin header, can now be installed. The shorting jumper can be installed in the "OFF" position (at right) for safe keeping, at this stage.

The three 7-way pin headers are installed on the copper side of the PC board, with their leads just protruding above the top surface. You will need a fine-tipped soldering iron to solder them in. Note that you will have to slide the plastic spacer along the pins to allow room for soldering, after which the spacer is pushed back down again.

Final assembly

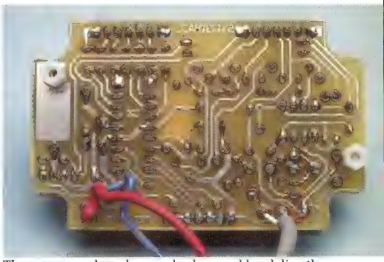
Work can now begin on the plastic case. First, remove the integral side pillars with a sharp chisel, then slide the microcontroller board in place. That done, mark out two mounting holes – one aligned with REG1's metal tab and the other diagonally opposite (to the bottom left of IC2).

Now remove the board and drill the two holes to 3mm. They should be slightly countersunk on the outside of the case to suit the mounting screws.

In addition, you will have to drill two holes in the bottom of the case to accept the power leads and the shielded cable for the Hall effect sensor. These two holes should be located so that they line up with the relevant PC stakes.

The display board can now be plugged into the microcontroller board and the assembly fastened together and installed in the case as shown in

Another view of the completed PC board assembly, prior to mounting in the case. Make sure that the displays are oriented correctly (decimal point to bottom right).



The power supply and sensor leads are soldered directly to their respective terminals on the back of the microcontroller board.

Fig.4. Be sure to use a 2mm nylon washer (or spacer) in the location shown.

Once it's all together, check that none of the leads on the display board short against any of the parts on the microcontroller board. Some of the pigtails on the display board may have to be trimmed to avoid this.

The front panel artwork can now be used as a template for marking out and drilling the front panel. You will need to drill a hole for the LDR plus a series of small holes around the inside perimeter of the display cutout.

Once the holes have been drilled, knock out the centre piece and clean up the rough edges using a small file. Make the cutout so that the red Perspex window is a tight fit. A few spots of superglue along the inside edges can be used to ensure that the window stays put.

That done, you can affix the front panel label and cut out the holes with a utility knife.

Testing

Before testing the unit, you have to connect the Hall sensor leads to the microcontroller board. These connections, along with the power supply connections are made on the copper sides (see photo).

Now apply power – the display should show two dashes (- -). After about 5 seconds, the display should then show a value on the 7-segment LED displays and one or more LEDs should light in the bargraph. If this doesn't happen, check the voltages on the Hall effect sensor. There should be +5V on pin 1, 0V on pin 2 and nominally 2.5V on pin 3 (this could be between 2.25V and 2.75V, depending on the particular sensor).

You can test the dimming feature by holding your finger over the LDR. Adjust VR1 until the display dims to the correct level. This trimpot is best adjusted when it's dark, to obtain the correct display brightness.

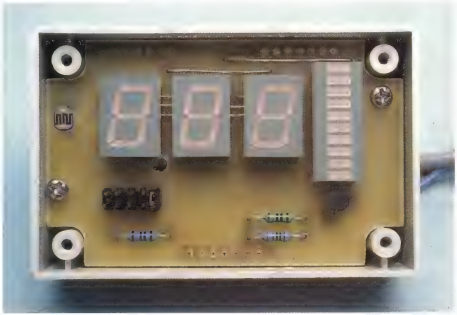
Calibration

The first calibration setting to be made is for the quiescent Hall effect output level. This is done by placing the jumper shorting plug across the "0" DIL launcher located on the display PC board. Just make sure the sensor is not located near any magnets when this is done.

The display should indicate "CAL" and the 0A LED should be lit on the bargraph display. Now remove the shorting plug after about one second and place it in the off position. The display will now return to normal operation and show a "0". Note that the off position is just a position to store the shorting plug and it does not form any connection to the circuit.

The unit must now be calibrated using a known current flow. The first step is to position the Hall effect sensor in the air gap of the ferrite core as shown in Fig.7.

In this case, the ferrite core is sim-



The PC board assembly fits neatly into a small plastic utility case and matches the style of our previous PIC-based automotive projects.

Table 3: Typical Lamp Ratings In Cars

Parking lights (front)	5W
Tail lights	5W
Licence plate	5W
Dashboard parking indicator	1.4W
Reversing lights	21W
Main brake lights	21W
High level brake light	18.4W
Dashboard brake indicator	1.4W
Headlights (high beam/low beam)	60W/55W
Dashboard high beam indicator	1.4W

Table 4: Total Load With Lights On (Typical)

Parking Lights + licence plate	25W (2.1A)
Reversing Lights	42W (3.5A)
Main brake Lights	42W (3.5A)
Main brake light + high level brake light	60.4W (5A)
Headlights (high beam, no low beam) + all brake lights + parking + licence plate	205.4W (17A)
Headlights (high beam with low beam) + all brake lights + parking + licence plate	315.4W (26A)

Fig.6: this is the full-size artwork for the front panel.

ply a voltage spike protector which is designed to clip over power leads to limit noise spikes. This unit uses a split core encased in a plastic housing that can be opened to accept the lead and then clamped shut again.

Fig.7 and the accompanying photos show how the Hall effect sensor is installed sandwich fashion between the two ferrite cores. The sensor board can be encapsulated in heatshrink tubing and attached to the side of the plastic case using a cable tie.

By the way, it's good idea to glue a couple of 1.5mm-thick plastic spacers either side of the Hall effect sensor, to prevent stressing the ferrite core when the case is closed.

Once the current sensor has been made up, clamp it to the battery lead(s). You can now calibrate the ammeter using either of two methods: (1) the "rough 'n ready" way using the current drawn by the car's headlights; or (2) the precise way by winding turns through the core to simulate a higher current.

We'll look at the rough 'n ready way first. Tables 3 & 4 show typical lamp ratings in cars and the currents drawn with various combinations of lights switched on. If you want better accuracy, check the ratings for the various lights in your vehicle, You should be able to get this information from the owner's handbook or from a service manual.

As stated previously, you need to calibrate at either 17A, 25A or 30A. From Table 3, you can see that if you switch on the headlights at high beam along with the brake lights and the parking lights, you will get a total current drain of about 26A (assuming a 12V battery).

This value should be satisfactory for calibrating the unit at 25A – just place the shorting jumper into the 25A position. The display will show "CAL" and the 25A discharge LEDs will light on the bargraph. That done, remove the jumper plug and replace it in the OFF position.

And that's it – the calibration is completed!

Note: some cars switch the low-beam lights off when the headlights are at high-beam and so the total current will only be around 17A. In this case, you calibrate the unit by placing the shorting plug in the 17A position.

Precise calibration

A more accurate calibration can be

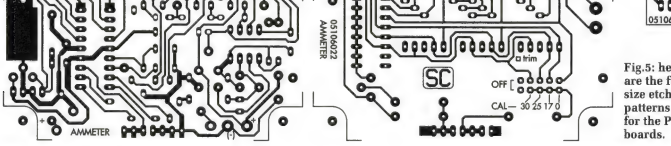
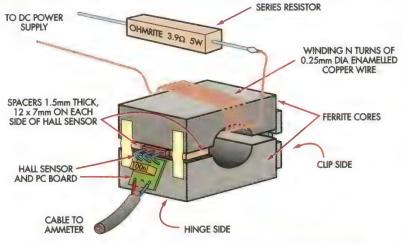


Fig.5: here are the full-size etching patterns for the PC boards.



SUPPLY VOLTAGE	N TURNS	RESISTOR	CALIBRATION (A)
3.9V	30T	3.9Ω 5W	30A
12V	80T	56Ω 5W	17A
12V	1T (BATTERY LEAD STRAIGHT THROUGH CORE)	NO RESISTOR (USE LIGHTS AS A CURRENT LOAD)	SEE TEXT AND TABLES 3 & 4

Fig.7: you can accurately calibrate the unit at low current using the set-up shown here (see text). Use silicone sealant to seal the assembly after clamping it to the battery leads and to protect the sensor board.

made at much lower current using either the car's battery or an adjustable or fixed 12V power supply. In this case, we simulate a higher current flow by winding many turns of wire through the ferrite core (see Fig.7). For example, if you want to simulate 30A, wind 30 turns on the ferrite core and set the current through these turns to 1A.

If you have an adjustable power supply, install a 3.9Ω 5W resistor in series with the power supply and the winding and set the output voltage to 3.9V. If you're really fussy, add a multimeter in series with the wiring and set the current to exactly 1A by adjusting the supply voltage.

When the current is at 1A, install the jumper in the 30A position. The display will show "CAL" and the 30A discharge LED will light. Remove the jumper short after about one second and the unit is accurately calibrated.

If you are using a fixed 12V supply, you can connect a 56Ω 5W resistor in series with 80 turns around the ferrite core. The 56Ω resistor sets the current at 214mA and the 80 turns simulates 17A through the core.

In this case, calibrate the unit using the 17A shorting position, then remove the jumper shorting plug after about one second.

The current sensor clamps onto the battery lead(s) as shown here. Make sure that all the leads to one battery terminal are included.

This view shows how the Hall effect sensor and the adjacent plastic spacer (or washers) are attached to the ferrite core.

Installation

The Ammeter can be installed into a vehicle using automotive style terminators to make the connections to the ignition supply and ground. Note that the ignition supply connection must be made on the fused side. The ground connection can be made to the chassis with an eyelet and self tapping screw.

Use twin core shielded cable for the 3-wire connection to the Hall sensor.

The Hall effect sensor should be attached to the ferrite core as shown in Fig.7, with the spacers installed and the assembly clipped together place. You can attach the core to either the positive or negative battery lead but all wires connecting to one battery terminal must pass through the core.

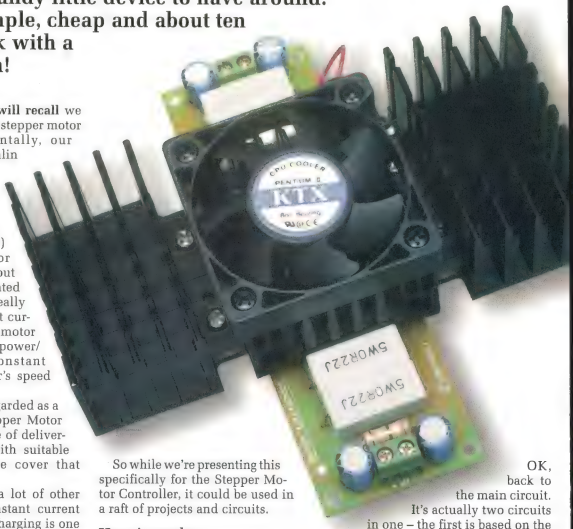
Check that the ammeter display shows the "-" sign when the battery is discharging. You can check this by switching on the headlights when the engine is off. If the minus sign is off, simply open the ferrite core, flip the assembly 180° and replace it over the wire or wires.

Finally, the Hall effect sensor assembly should be tied together with cable ties and covered with a layer of silicone sealant to keep dirt and moisture out. The PC board and wiring should also be covered with the Silicone and the lead secured with cable ties. **SC**

Constant, High-Current Source

By Ross Tester

Whether it's for charging batteries or in more esoteric applications like stepper motors, a source of reasonably high level constant current is a handy little device to have around. This one's simple, cheap and about ten minute's work with a soldering iron!



Last month, you will recall we presented a mini stepper motor driver. (Incidentally, our apologies for the gremlin which got into the system and caused most of the earth symbols and one resistor to disappear. No, we don't know why either!)

That stepper motor driver operates from about 8-35V DC but as we pointed out, a stepper motor really likes to have a constant current source so that the motor current (and therefore power/torque) remains constant throughout the stepper's speed range.

This, then, can be regarded as a companion to the Stepper Motor Controller. It is capable of delivering more than 10A with suitable heatsinking – and we cover that shortly.

However, there are a lot of other applications for a constant current source. Nicad battery charging is one which immediately springs to mind. Anything where the constant colour temperature of a globe is important (such as phototographics) is another. And in electronics, there are countless occasions where constant current circuits are used.

So while we're presenting this specifically for the Stepper Motor Controller, it could be used in a raft of projects and circuits.

How it works

Let's get REG1, a 7812, out of the way first of all since it has nothing to do with the constant current source. Its is obviously a constant voltage source and its sole task is to supply 12V DC to the heatsink fan.

OK, back to the main circuit. It's actually two circuits in one – the first is based on the LM317 adjustable regulator.

As you can see, the "ADJ", or adjustment, terminal is connected to the output via a resistor.

The voltage between the adjustment terminal and the output terminal is always 1.25V, so a constant current of

1.25/R is established.

The LM317 is rated at a maximum output current of 1.5A, so in theory this resistor could be as low as about 0.83Ω (1.25/.83 = 1.5).

But that's sailing pretty close to the wind, despite the LM317's ability to shut down if it gets too hot under the collar.

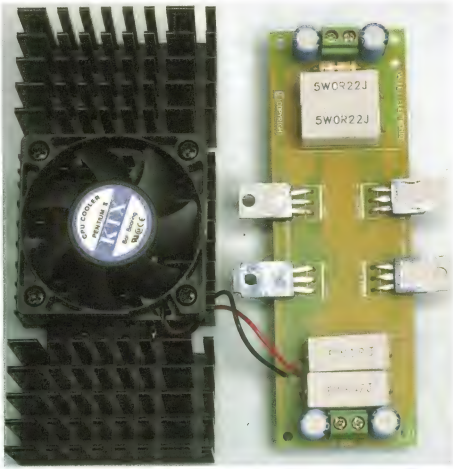
A much better approach is to add a current 'amplifier' to increase the output. That's the purpose of Q1 & Q2 which are 'slaved' to the LM317 so that it does not have to work so hard.

The circuit works in the following way: say the LM317 was carrying 500mA as its share of the load current. Ignoring the base current of Q1 & Q2 for the moment, that would mean we have 500mA passing through the 3.9Ω resistor at its input.

With that current, we must have 1.95V (3.9 x 0.5) across the resistor and it is this voltage which controls Q1 and Q2 which effectively work as emitter followers, applying 1.3V across their 0.22Ω resistors. This forces each transistor to carry 5.9A, giving a total of 12.3A for the circuit.

In practice, we have to allow for the base currents drawn by the two transistors but the result will still be a total current of around 12A when REG1 is carrying 0.5A.

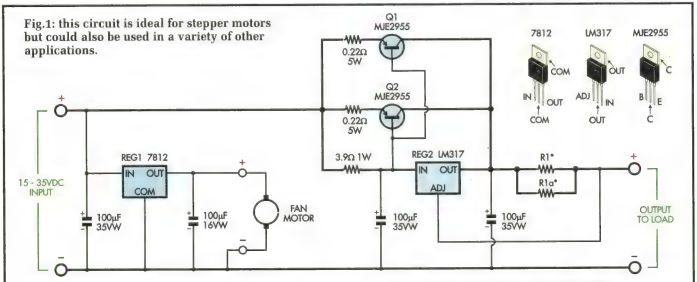
Whether the circuit can actually supply 10A will depend on the overall dissipation and this is the product of the difference between the input and output voltages and the desired current.



This shot shows the two halves of the project opened out – the Pentium II heatsink with its integral fan on the left and the controller itself on the right. The lower two resistors are chosen according to the output current.

For example, if you have an input voltage of 25V and you are using the circuit to supply 10A to a load which requires 12V (eg, two 12V 50W halogen lamps), the difference voltage across the circuit would be 25-12 = 13V and therefore the total dissipation would be 13 x 10 = 130W. Would

Fig.1: this circuit is ideal for stepper motors but could also be used in a variety of other applications.



CONSTANT CURRENT SOURCE

Parts List – Constant Current Source

- 1 PC board, 75 x 30mm, coded K-142c
- 1 Pentium II-type heatsink and 12V fan assembly
- 2 2-way PC-mount terminal blocks
- 4 M3 10mm screws & nuts
- 4 sets TO-220 insulating washers & bushes

Semiconductors

- 2 MJE2955 PNP power transistors (Q1, Q2)
- 1 7812 12V positive voltage regulator (REG1)
- 1 LM317 adjustable voltage regulator (REG2)

Capacitors

- 4 100µF 35VW electrolytics

Resistors

- 2 0.22Ω, 5W
- 1 3.9Ω, 1W
- 2 5W resistors to suit output current – see text & tables

the circuit be able to cope with this, even with the fan-cooled heatsink? Highly unlikely, so you see that if we want 10A, we need to reduce the input voltage (or increase the output voltage) to get the overall power dissipation down.

However, the beauty of this circuit is that it can't overheat because the LM317 is on the same heatsink as the two transistors, so if they start to get really hot, so does the LM317 and it then shuts down before damage can occur.

So there it is. A handy constant current circuit but you have to make decisions about input voltage, output voltage and current to get the best out of it.

Construction

Everything – the components and fan-cooled heatsink – are mounted on a PC board measuring 125 x 40mm and coded K-142c.

In fact, the heatsink is not actually connected to the PC board – it is screwed to the two power transistors and two regulators which of course are soldered to the board.

Start by checking the board for any defects (rare these days, but possible) and solder on the 3.9Ω 1W resistor and the two 0.22Ω 5W resistors at one end.

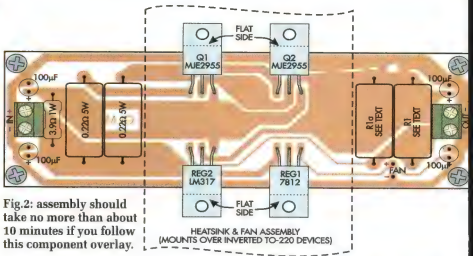


Fig.2: assembly should take no more than about 10 minutes if you follow this component overlay.

Next, solder on the four electrolytic capacitors and the two PC-mounting terminal blocks.

The two 5W resistors at the other end must be chosen for the output current required. As shown in the tables, they can be series or parallel connected.

If you are going to parallel them, great – that's the way the board has been set up. Simply choose the two

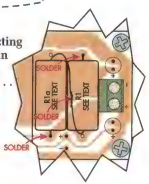
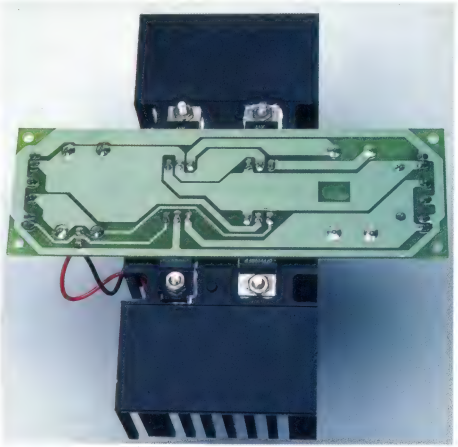


Fig.3: connecting R1 and R1a in series is a bit more tricky . . .



The upside-down view of the completed assembly. The heatsink is held onto the PC board by the four screws and nuts through the transistors and regulators.

resistor values you want and solder them in. If you have to series them, you'll need to be a bit cleverer! Only one (opposite) end of each resistor is soldered to the PC board; the other ends must connect together across the top of the board.

Either way is fine but the parallel arrangement is just a bit neater. The downside of parallel resistors is that when they are unequal, they have different power dissipations. Ideally, they should be fairly close values.

Now we come to the tricky bit – soldering in the two transistors and two regulators. First of all, note carefully their positions on the PC board. The second thing to note is that they are actually soldered in "upside down" compared to normal.

If you lay the devices flat on their backs, all legs have to be bent **up** 90° to go through the PC board. The exact position of the bend depends on where the holes are in the heatsink – you have to be pretty accurate to get them all to line up. See Fig.4 for more details on the way the heatsink and transistors mount together.

And make sure you get the right one in the right place. They're all TO-220 packages so it's easy to get them mixed up!

Ideally, all should be fitted with insulating washers – the tabs should not be connected together.

Well, to be truthful, the tabs of the LM317 (OUT) and the MJE2955 (C) are all connected together anyway (via their pins) so they can all be shorted together via the heatsink without any particular concerns.

But the tab of the 7812 **must** be insulated from the other three devices. (Note that the 7812 in the Oatley kit has an isolated tab so no washers are required on any of the devices and none are supplied in the kit.)

You'll find it easier to fit the heatsink before you fit the fan – there's not much room between the fan and fins to fit a screwdriver.

The fan screws to the heatsink with four long self-tappers. It matters little which way up it goes – one way sucks air through the heatsink, the other pushes air through the heatsink. However most fans are polarised – you must get the red wire on the +12V pin and the black on the –ve pin.

And, apart from mounting the assembly in a suitable case, that completes the construction side.

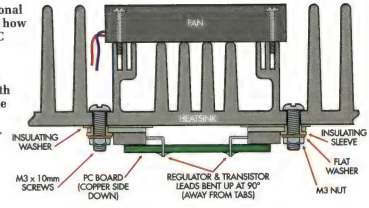


Fig.4: this sectional diagram shows how to mount the PC board to the heatsink/fan assembly. Take special care with the bends on the regulators and transistors.

In use

We're not even going to attempt to go there: if you are building a constant-current supply, you know what you are going to do with it and how to connect it! Just bear in mind the limits we placed on the output current.

Of course, if you wanted industrial-strength muscle, there would be nothing to stop you adding some more MJE2955s in parallel (with their load-sharing resistors) mounted on an even bigger heatsink (also fan assisted).

But you're very quickly going to reach the point where the tracks on the PC board won't handle the current without significant thickening. (You could solder wire over the tracks).

Wheredyageddit?

The design and PC board pattern is copyright © Oatley Electronics.

A complete kit of parts including PC board, components and the Pentium II fan/heatsink assembly is available from Oatley Electronics for $29.00.

This includes the two 0.22Ω 5W resistors and 1Ω and 0.47Ω 5W resistors for R1 & R1a, selected to give an output current of about 3.8A with the resistors in parallel (0.32Ω).

Oatley Electronics are at PO Box 89, Oatley NSW 2223, phone (02) 9584 3563, fax (02) 9584 3561, email sales@oatleyelectronics.com; or they can be contacted via their website: www.oatleyelectronics.com **SC**

TABLE 1: Values for SERIES combinations of resistors R1 & R1a

R1↓ R1a→	0.1Ω	0.22Ω	0.47Ω	1.0Ω	1.2Ω	1.5Ω	2.2Ω	3.3Ω	4.7Ω	5.6Ω
0.1Ω	0.2Ω	0.32Ω	0.57Ω	1.1Ω	1.3Ω	1.6Ω	2.3Ω	3.4Ω	4.8Ω	5.7Ω
0.22Ω		0.44Ω	0.69Ω	1.22Ω	1.42Ω	1.72Ω	2.42Ω	3.52Ω	4.92Ω	5.82Ω
0.47Ω			0.94Ω	1.47Ω	1.67Ω	1.97Ω	2.67Ω	3.77Ω	5.17Ω	6.07Ω
1.0Ω				2.0Ω	2.2Ω	2.5Ω	3.2Ω	4.3Ω	5.7Ω	6.6Ω
1.2Ω					2.4Ω	2.7Ω	3.4Ω	4.5Ω	5.9Ω	6.8Ω
1.5Ω						3.0Ω	3.7Ω	4.8Ω	6.2Ω	7.1Ω
2.2Ω							4.4Ω	5.5Ω	6.9Ω	7.8Ω
3.3Ω								6.6Ω	8.0Ω	8.9Ω
4.7Ω									9.4Ω	10.3Ω
5.6Ω										11.2Ω

How easy is this: these tables give various likely combinations of R1 and R1a in series and parallel – simply divide the figure in black into 1.25 to get the output current you want!

TABLE 2: Values for PARALLEL combinations of resistors R1 & R1a

R1↓ R1a→	0.1Ω	0.22Ω	0.47Ω	1.0Ω	1.2Ω	1.5Ω	2.2Ω	3.3Ω	4.7Ω	5.6Ω
0.1Ω	0.05Ω	0.069Ω	0.082Ω	0.09Ω	0.092Ω	0.094Ω	0.096Ω	0.097Ω	0.098Ω	0.098Ω
0.22Ω		0.11Ω	0.15Ω	0.18Ω	0.186Ω	0.192Ω	0.20Ω	0.206Ω	0.21Ω	0.212Ω
0.47Ω			0.235Ω	0.320Ω	0.338Ω	0.358Ω	0.387Ω	0.411Ω	0.427Ω	0.434Ω
1.0Ω				0.50Ω	0.545Ω	0.60Ω	0.688Ω	0.767Ω	0.825Ω	0.848Ω
1.2Ω					0.60Ω	0.666Ω	0.776Ω	0.88Ω	0.956Ω	0.988Ω
1.5Ω						0.75Ω	0.892Ω	1.03Ω	1.137Ω	1.183Ω
2.2Ω							1.1Ω	1.32Ω	1.499Ω	1.579Ω
3.3Ω								1.65Ω	1.94Ω	2.076Ω
4.7Ω									2.35Ω	2.555Ω
5.6Ω										2.80Ω

VINTAGE RADIO

By RODNEY CHAMPNESS, VK3UG

The 1935 Tasma M290 Console

In the 1920s, 30s & 40s, console radios graced the lounges of many homes in Australia. They were beautiful pieces of furniture and were the centre of attraction in whatever setting they were placed. And they poured forth beautiful music, the news and serials, forming the entertainment focus for the household.

Thom and Smith Limited of Sydney were a moderate-sized manufacturer of radio and other electronic equipment throughout the 1930s. As a result of their versatility and product quality, they were engaged by the Government during WWII to produce medium-power radio communications transmitters and other ancillary equipment for the services.

Many of the transmitters saw service after the war in communications networks such as the Flying Doctor Service.

By 1935, most manufacturers had changed over from the tricky autodyne converter valve to the triode hexode converter or other purpose designed converter/mixer valves. The Tasma M290 had one of the new European EK1 converter valves, which was followed by a 6D6 as an IF amplifier, a 75 as a detector, AGC diode and audio amplifier, followed finally by a 42 as the audio output.

The circuit of four valves and a rectifier became almost the generic standard for broadcast domestic entertainment receivers throughout the rest of the valve radio era.

On looking at the circuit, it appears to be quite normal for the era. There is a large tapped voltage divider, near capacitor 9, used to select the voltage for the screens of the converter and IF amplifier stages. It is the large green resistor shown in the under chassis view. Tasma were one of the few manufacturers who woke up to the fact that local oscillators work best if the padder (16) is placed in the circuit as shown,

The Tasma M290 console has a rather boxy cabinet but quite an ornate dial. As shown above, this dial is attached to the chassis, making service and alignment that much easier.

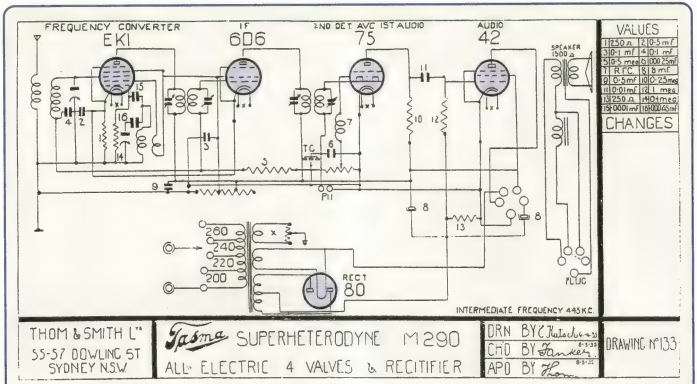


Fig.1: the circuit of four valves and a rectifier was typical for a 1930s radio receiver. Note that this circuit has a number of errors which are referred to in the text.

rather than in series with the earth end of the oscillator tuning coil.

The IF transformers are tuned by trimmer capacitors which was the common method at that time. The intermediate frequency (IF) is a little lower than usual, at 445kHz, although at that stage 455kHz was not anywhere near universal. The detector and audio stages are quite conventional. The power transformer is tapped so that input voltages of between 200 and 260VAC can be used.

For some reason or other, the selection of the voltages is via a switch on the back of the chassis. It seems hardly necessary to have a switch when a soldered fly lead could select the appropriate tapping. It wasn't as if radios, particularly consoles, were shifted regularly from area to area where different mains voltages were in use.

Close inspection of the circuit diagram reveals some errors, as the 75 would be destroyed if they were correct. "TC" is the tone control, shown with one capacitor on a 3-position switch. However, inspection of the set reveals that the it switches various capacitors and the moving arm (wiper) goes to earth. In the circuit as drawn, high tension (HT) is applied to the detector/AGC diode which would destroy the valve and maybe also the IF transformer.

The volume control is the load for the diode detector/AGC diodes. As the strength of the signal increases, the negative voltage across the volume control would increase as needed for the automatic volume control (AVC/AGC) action. As the volume control is rotated to increase the volume, the bias on the 75 would also increase,

This rear view of the chassis shows a conventional layout. The chassis-mount electrolytics are now dummies, having been replaced by modern capacitors under the chassis.

Access under the chassis is only average, with the tagboard obscuring the valve sockets. Note the replacement pigtail electrolytics near the transformer.

This rear view of the console shows the sloping shelf for the chassis, made necessary by the sloping front of the cabinet.

tending to cut the valve off. In fact, that definitely happens and results in no audio.

It seems that a DC blocking capacitor and a resistor are missing from this part of the circuit. The use of an RF choke (7) to filter out any remaining IF energy on the signal to the audio amplifier is uncommon. If it has an inductance of around 2.5 millihenry (a common value) the reactance (RF resistance at 445kHz) would be around 9kΩ. Most manufacturers found it was more effective and cheaper to use a resistor of around 50kΩ to act as an intermediate frequency filter element.

The speaker is shown as 1500Ω. Perhaps the field coil is 1500Ω as the 42 requires a plate load impedance of around 7kΩ.

We've come to expect that circuit diagrams are accurate. As can be seen in this case, they are often inaccurate despite being drawn, checked and approved by people familiar with the design. They would probably be more accurate if the original drawings were laid out just a bit more logically with better spacing between parts of the diagram which are currently crowded. But Thom and Smith were not the only ones who allowed errors to creep into their circuits.

Dealing with the cabinet

The cabinet is rectangular with no curved edges, which makes it look rather "boxy". The cabinet was in reasonable condition when obtained. It responded well to the use of paint stripper to remove the original finish. The black trims were painted and the cabinet was finished with satin/semi-gloss clear pre-catalysed lacquer spray (Mirotone). The excellent result of this work can be seen in the photographs.

The yellowed celluloid dial protection was replaced with a piece of acetate sheet from a shirt packet and now the dial looks like new. Acetate sheet can also be obtained from art and craft shops. The dial mechanism itself is dual speed with a "band-spread" dial at the bottom; quite handy for accurate tuning.

The controls on the set follow a logical sequence, with the lefthand one being volume, the centre one being tuning and the righthand one a tone control. All in all, it is quite an attractive set.

Gaining access to the chassis

The front of the set where the controls are is sloped, which means that the shelf the chassis sits on is also at an angle. To remove the chassis from the cabinet requires the removal of the three control knobs, the speaker plug and finally, four nuts and bolts which secure the chassis to its mounting shelf. These nuts and bolts are awkward to remove or reinstall.

The chassis was a bit scrappy so it was cleaned down, primed and finally painted with brown gloss spray paint. Some of the parts were removed from the chassis while others were

very carefully masked to ensure a quality paint job. The owner of the set is renowned for the quality of his workmanship, which is very obvious in the photographs.

Inspection of the chassis electronics revealed that the EK1 had been replaced by a 6A8G at some stage in the past. This also required replacement of the valve socket. Most of the paper capacitors and electrolytic capacitors were replaced. The large chassis-mount electrolytic capacitors were left in-situ to keep the set looking as authentic as practical. The replacement capacitors can be seen in the under-chassis view near the power transformer. A few out of tolerance resistors required replacement too.

The electrodynamic speaker was defective and was replaced with a permanent magnet unit while the field coil was replaced with a 2.5kΩ 20W wirewound resistor.

A number of perished wires and the power cord were replaced. The original cord would have been a twin-conductor cord in a brown fabric sheath. Burton Cables have made modern 3-core cable with a brown fabric sheath. However, I am unsure whether that is still available. As has been common over the years, the power lead has been knotted. The current official practice is for power leads to be restrained within an appliance by a clamp, with the earth lead going to a crimped or soldered lug which is bolted to the frame.

Manufacturers of the era tended to put most components on tagstrip boards. Thom and Smith were no exception. They, like many others, put these boards over the top of other components or valve sockets which often made access and troubleshooting a slow job.

Having done all this work, the set was aligned and the performance was quite good. These old sets can put in quite a creditable performance.

Summary

The Tasma M290 console receiver was produced at a time when much experimentation and improvement in design and style was taking place. It may not be the most elegant console around but it is a good honest set. The manufacturers could have made access for service easier under the chassis and they should hang their heads in shame over the circuit diagram inaccuracies.

This dial is almost in mint condition. Note the smaller bandspread dial for fine tuning.

These criticisms aside, it is a good performer that gave the owner no unpleasant surprises during the restoration. It is a set well worth having in any collection – if you have the room. This is why I think few collections have more than one or two consoles. They are a beautiful piece of furniture and the tonal quality of the better units is good even by today's standards. **SC**

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Last month, we introduced the subject of fuel cells and outlined how they are being researched by many major car manufacturers around the world. In this issue, we look more closely at the main types of fuel cells and how they work.

Fuel Cells Explode!

By GERRY NOLAN

There's been an explosion in the number and type of fuel cells – either in production, in testing or in design. Fuel cell and vehicle manufacturers around the world are confidently predicting virtually zero-polluting, fuel-cell powered models entering the mainstream market perhaps as early as 2005 – and certainly by 2010. (See SILICON CHIP May 2002).

This month, we're looking at the various types of fuel cells, how they work and how they differ from one another. We even look at some which are still very much in the "concept" stage but which show great promise.

Main types

The main fuel cell types are alkaline fuel cell (AFC), polymer electrolyte membrane (PEMFC), also known as the proton exchange membrane, direct methanol (DMFC), molten carbonate (MCFC), phosphoric acid (PAFC), solid oxide (SOFC) and protonic ceramic fuel cell (PCFC).

Although we indicated last month that there were five main types of fuel cells, we'll treat the direct methanol fuel cells, which are quite similar to polymer electrolytic membrane fuel cells, separately. We'll also look briefly at regenerative fuel cells (RFC) and zinc-air fuel cells (ZAFC).

Fuel cells are classified by the type of electrolyte they use. This may be acidic or alkaline and is either liquid, generally in a porous matrix, or a high temperature solid state electrolyte present as a ceramic material in the solid oxide (SOFC) and proton ceramic fuel cells (PCFC).

A circulating liquid electrolyte has the advantage that it can be used to manage heat removal and adjust the electrolyte concentration and water balancing while it is in operation. Sloshing of the electrolyte can be prevented by using a micro-porous matrix or by crystallising or gelling the electrolyte as in a PAFC. In the PEMFC, the polymer electrolyte membrane functions as a fixed acidic electrolyte.

General overview

First, let's discuss how a generic fuel cell works before we move on to specific types and their operation. As shown in the diagram of Fig.1, hydrogen is fed into the anode and oxygen enters through the cathode. Under the influence of a catalyst, each hydrogen atom splits into a proton and an electron which are forced to take different paths to the cathode. The protons pass through the electrolyte while the electrons return to the cathode, where they rejoin with the hydrogen and oxygen to form a molecule of water.

The electron flow can be used in any way that an electric current from a generator or battery could be used, for example, to power a car, appliance or anything you like. Since fuel cells rely on a controlled chemical reaction and not the relatively uncontrolled combustion of an internal combustion engine, emissions from fuel cells are much lower.

In fuel cells with an acidic electrolyte, positively charged hydrogen ions (protons) migrate from the anode, also called the fuel electrode, to the cathode, also called the air electrode, where water is produced. In alkaline fuel cells, the charge is carried by negatively-charged ions and the water is produced at the hydrogen electrode (anode).

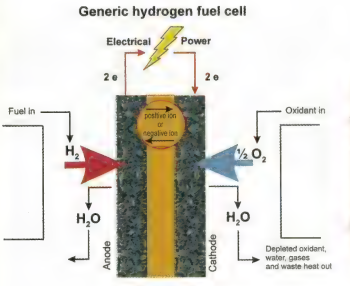
In principle, any exothermic chemical reaction (ie, where heat energy is released) can be used to generate electricity. All fuel cells convert chemical energy into

This one-kilowatt portable Ballard fuel cell generator demonstration unit is a fully automated power system which converts hydrogen fuel and oxygen from air directly into DC electricity. Water is the only byproduct of the reaction. It operates at low pressures, provides reliable, clean, quiet and efficient power and is small enough to be carried to wherever power is needed. (Photo courtesy Ballard Power Systems).

electric energy and if suitable electrodes and an electrolyte to support the reaction can be provided, a fuel cell system can utilise the hydrogen from any hydrocarbon fuel, such as natural gas, methanol and even petrol.

In the old way, fuels such as propane, petrol, diesel or hydrogen are burnt in an internal combustion engine or in a furnace, with the heat energy being converted to mechanical energy in a piston engine or a turbine, which drives a generator to produce electricity. In general, these thermodynamic processes are quite inefficient and this is made worse by the moving parts in a reciprocating engine, so that typically the efficiency is 20-30% at best.

Hydrogen-oxygen fuel cells are far better and can achieve efficiencies in the range of 60-70%.



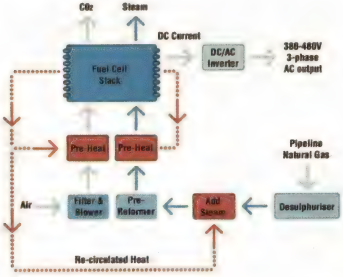


Fig.1a (left) shows the components and chemical reactions occuring in a generic hydrogen fuel cell. In a typical stationary power generation unit (Fig.1b, right), the fuel cell hydrogen is derived from natural gas, using some of the byproduct heat energy from the fuel cell itself. (Courtesy Ballard Power Systems).

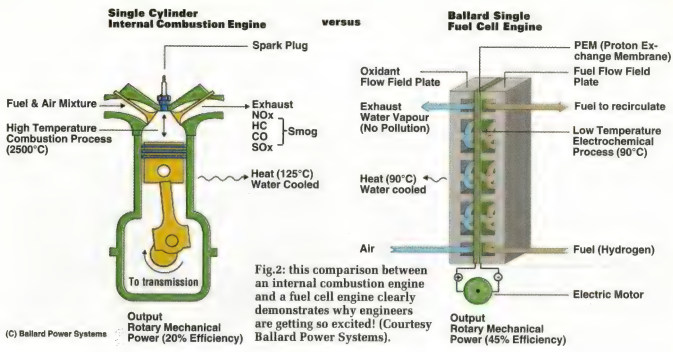


Fig.2: this comparison between an internal combustion engine and a fuel cell engine clearly demonstrates why engineers are getting so excited! (Courtesy Ballard Power Systems).

Unfortunately, hydrogen is not a readily available fuel so efforts have to be made to convert hydrocarbon fuels into pure hydrogen and carbon dioxide.

Alkaline fuel cells

As discussed in last month's issue, Francis T. Bacon developed the first successful fuel cell in 1932, using hydrogen, oxygen, potassium hydroxide as the electrolyte and nickel electrodes. So alkaline fuel cells were the first to be used successfully.

Thirty years later, Bacon and a co-worker produced a 5kW fuel cell system and it is history that the Bacon design was chosen by NASA over nuclear power and solar energy, as the power supply for the Apollo and Gemini missions and the shuttle orbiters – incidentally providing water as well as electricity. These cells can now achieve electrical generating efficiencies of up to 70% with outputs that range from 300W to 5kW.

Alkaline fuel cells, (AFCs) generally use solutions of sodium hydroxide (NaOH) or potassium hydroxide (KOH) – see Fig.3. The cathode reaction is faster in the alkaline electrolyte, resulting in higher performance. However, a major disadvantage of AFCs is that the alkaline electrolytes react with carbon dioxide to precipitate carbonates.

If there is any carbon dioxide present, it will quickly degrade the electrolyte and reduce the efficiency of the cell. As a result, AFCs are typically restricted to specialised applications where pure hydrogen and oxygen are used, such as low power aerospace and defence applications. They are considered too costly for commercial applications but several companies are working to reduce costs and improve operating flexibility.

Alkaline fuel cell manufacturers still claim advantages for their cells over the proton membrane exchange (PEM) and other acid types, stating that an alkaline fuel cell with a circulating liquid electrolyte would be a better choice than PEM fuel cells for electric vehicles and on-site power systems. One of the reasons given is that AFCs are much less expensive to build than PEMs because they contain less noble metal catalyst material – platinum and palladium are very expensive.

The cost of the AFC is becoming as low as US$200 to $300 per kilowatt without accessories and US$400 to $600 with accessories, while the cost of the PEM is a factor of 10 higher with or without accessories, partly because AFCs require less accessory equipment.

Some of the accessory equipment that is required for PEMs and not for AFCs are air-compressors and humidifiers. This accessory equipment uses power, which reduces the overall efficiency of the PEM system, as well as making it less convenient to use.

Another advantage is that AFCs produce a higher voltage than PEMs. The cell operating voltage of an AFC is 0.8V while the PEM is 0.6V; 100 AFC cells produce 80V, while 100 PEM cells produce 60V.

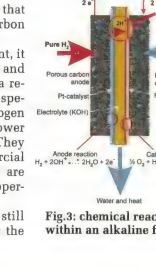


Fig.3: chemical reactions within an alkaline fuel cell.

While PEM cells cannot be conveniently shut down for extended periods, AFCs can be shut down for as long as required for maintenance or rest, which is quite important. Instead of separators which must be kept moist at all times, AFCs have a built-in circulating electrolyte system so there is no water-buildup problem and humidifiers and air compressors are unnecessary. Shutting down an AFC is as easy as turning off the switch, after which the electrolyte is automatically removed from the stacks, making the AFC inactive.

AFCs operate on hydrogen derived from ammonia and, being rich in hydro-

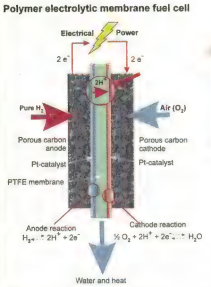


Fig.4a: the components and chemical reaction in a PEMFC.

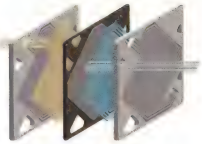


Fig.3b (above) reveals detail of a Ballard fuel cell stack showing the flow field plates which supply the bodies of fuel and air to either side of the proton exchange membrane. Stacking more cells together increases the voltage produced; increasing the cell's surface area increases the current produced.

gen, anhydrous ammonia (NH3) is one of the best carriers of hydrogen. As it is not a hydrocarbon, it does not produce any harmful emissions. AFCs can use hydrogen produced by an ammonia cracker but PEM fuel cells cannot. This is because this hydrogen carries with it a trace of ammonia gas which the PEM fuel cell, being acidic, cannot tolerate.

What do we conclude from this? Although most vehicles on the verge of production are using acid-type cells (quite often PEMFC), manufacturers of AFCs have not given up. But it's early in the story yet. Let's go on and see what the others have to offer.

Proton exchange membrane fuel cells

Proton exchange membrane fuel cells (PEM), (also known as polymer electrolytic fuel cells) are currently the most common type of fuel cell being developed for use in vehicles. The reasons for this are mainly that they use inexpensive manufacturing materials, ie, plastic membrane, they react quickly to changes in electrical demand and do not leak or corrode. They also operate at relatively low temperatures, 80°C, for greater efficiency and have high power density.

Because their power output can change quickly to meet shifts in power demand, they are suited for motor vehicles where quick startup is required.

The proton exchange membrane, which allows hydrogen ions to pass through it, is a plastic sheet, typically 0.2mm thick, coated on both sides with highly dispersed metal alloy particles, mostly platinum, that are active catalysts. The electrolyte used is a solid organic polymer, poly-perflourosulfonic acid. Using a solid electrolyte has the advantage of reducing corrosion and management problems.

Hydrogen is fed to the anode side of the fuel cell where the catalyst promotes the separation into hydrogen ions and electrons – see Fig.4. The electrons are passed through an electric load (eg, electric motor) before returning to the cathode side of the fuel cell to which oxygen has been supplied.

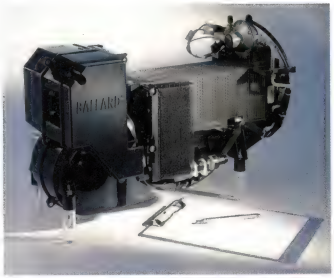
While the electrons are taking the long way around, the protons diffuse through the electrolyte directly to the cathode. Here the hydrogen ion recombines with its electron and reacts with oxygen to produce water, thus completing the overall process. PEM fuel cell output is generally in the range from 50W to 250kW.

Direct methanol fuel cells

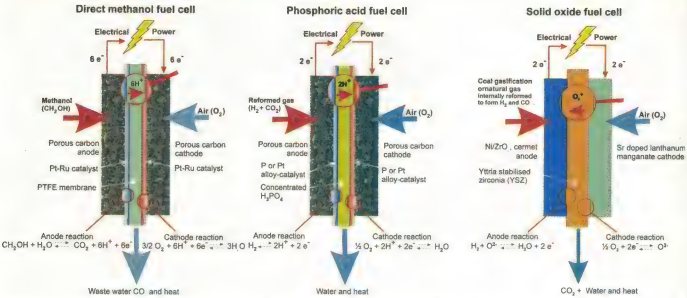
These are like PEM cells but instead of pure hydrogen they use a methanol-water solution. This is introduced to the fuel electrode, where the anode catalyst extracts the hydrogen in a spontaneous reaction which splits the methanol molecules, freeing the hydrogen and allowing the carbon atom to combine with the oxygen atoms from the methanol to form carbon dioxide. Because methanol readily frees its hydrogen to react in the fuel cell, it is an ideal carrier, eliminating the need for a fuel reformer or to have a fuel tank of pure hydrogen – see Fig.4.

In the process of splitting the methanol molecules to free hydrogen, the catalyst at the anode promotes the electrochemical oxidisation of the released hydrogen to produce electrons which travel through the external circuit back to the cathode electro-catalyst. This promotes the reduction reaction to combine the electrons with oxygen. As in the PEM fuel cell, the circuit is completed within the cell by protons passing through the electrolyte.

Operating temperatures of direct methanol fuel cells are in the same range as PEM cells, 50-100°C, which achieves efficiencies of about 40%. The low temperature range makes this type of fuel cell a possibility for use in small to mid-sized applications such as mobile phones and laptop computers. Due to their simplicity, direct methanol fuel cells are also being considered for use by the transportation industry.



The first commercial PEM fuel cell module, designed for integration into a range of stationary and portable power generation applications. (Courtesy Ballard Power Corp).



Figs.5, 6 & 7: the chemical reactions in direct methanol, phosphoric acid and solid oxide fuel cells.

Molten carbonate fuel cells

These are second-generation fuel cells designed to operate at higher temperatures than phosphoric acid or PEM cells. Because molten carbonate technology is specifically designed to operate at the higher temperatures it is able to achieve higher fuel-to-electrical output and overall energy use efficiencies than lower temperature cells. At these temperatures, the electrolyte solution of lithium, sodium and/or potassium carbonates soaked in a matrix becomes molten and able to conduct charged particles (ions) between the two porous electrodes.

Molten carbonate fuel cells are at the high power end, with units achieving outputs of up to 2MW while there are designs on the drawing board for units up to 100MW!

The nickel electrode catalysts of molten carbonate fuel cells are inexpensive when compared with other catalysts and they promise high fuel-to-electrical output efficiencies – about 60% normally or 85% with co-generation. However, the high operating temperatures, typically 650°C, limit the practicality of these cells for many applications.

However, the high operating temperature is not all bad news. It allows much greater flexibility in types of fuels and inexpensive catalysts because the reactions involved in breaking the carbon bonds in larger molecule hydrocarbon fuels occur much faster as the temperature is increased. Molten carbonate fuel cells have been run on hydrogen, natural gas, propane, landfill gas, marine diesel and simulated coal gasification products. These cells are mainly intended for use in electric utility applications and have been successfully demonstrated in this role in Japan and Italy.

When natural gas is used as the fuel, methane and steam are converted into a hydrogen-rich gas inside the fuel cell stack in a process called 'internal reforming'. The hydrogen produced reacts with the carbonate ions (CO_3) at the anode to produce water, carbon dioxide and electrons. As with all cells, the electrons travel through an external circuit before returning to the cathode. At the cathode, oxygen from the air and carbon dioxide recycled from the anode react with the electrons to form CO_3 ions that replenish the electrolyte and flow through the fuel cell, completing the circuit.

Molten carbonate fuel cells eliminate the external fuel processors that other fuel cells need to extract hydrogen from the fuel.

In reaching efficiencies approaching 60%, molten carbonate cells are considerably more efficient than the 37-42% of a phosphoric acid fuel cell plant. Further, when the heat produced is used for space or water heating, the overall efficiency can be as high as 85%.

Phosphoric acid fuel cells-PAFC

These were the first fuel cells to become commercially available in the electric power industry. More than 200 of these 'first generation' phosphoric acid fuel cell systems have been installed all over the world, in hospitals, nursing homes, hotels and so on, including one that powers a police station in New York City's Central Park. From this, it is apparent they are more suited to a stationary type of application.

Efficiency ranges from 40-80% and the operating temperature is 1500-2000°C. At lower temperatures, phosphoric acid is a poor ionic conductor and carbon monoxide (CO) poisoning of the platinum (Pt) electro-catalyst in the anode becomes severe.

Existing PAFCs have outputs up to 200kW and 11MW units have been tested. As already indicated, PAFCs generate electricity at more than 40% efficiency and, when the steam it produces is used for cogeneration, efficiency rises to nearly 85%. This compares to about 35% efficiency for a typical electrical power grid.

Apart from the nearly 85% cogeneration efficiency, one of the main advantages is that it can use impure hydrogen as fuel. Operating at the right temperature, PAFCs can tolerate a CO concentration of about 1.5%, which increases the range of fuels they can use. However, if petrol is to be used, any sulphur content must be first removed.

Now what are the problems with phosphoric acid fuel cells that make the molten carbonate fuel cells so much more attractive? They use expensive platinum as a cata-

lyst and only generate low current and power per cell, making them generally much larger and heavier than other types of fuel cells for the same total power output. However, PAFCs are the most mature fuel cell technology and for the present, that means tried and tested reliability.

Solid oxide fuel cells

This is a promising new fuel cell which an Australian company, Ceramic Fuel Cells Ltd, with the collaboration of the CSIRO, has concentrated on. It has the potential to be used in high-power distributed generation applications, including large-scale electricity generating stations. Some developers are promoting SOFCs for motor vehicles and are developing auxiliary power units using SOFCs.

Solid oxide fuel cells are a different branch altogether of fuel cell technology – see Fig.7.

The anode, cathode and electrolyte are all made from ceramics, which enables the cells to operate at temperatures significantly higher than any other mainline fuel cell. They also produce exhaust gases at temperatures ideal for cogeneration for use in combined-cycle electric power plants.

The fact that the cells can be produced as rolled tubes or flat plates enables them to be manufactured using many of the techniques presently used by the electronics industry. Although a variety of oxide combinations have been used for solid oxide electrolytes, the most common so far has been a mixture of zirconium oxide and calcium oxide formed as a crystal lattice and stabilised with yttria – usually called YSZ or yttria stabilised zirconium.

At the high operating temperatures, oxygen ions are formed at the 'air electrode', a ceramic cathode conducting perovskite, lanthanum manganate ($LaMnO_3$). A fuel gas containing hydrogen is passed over the 'fuel electrode', the anode, typically formed from a nickel/yttria-stabilized zirconia cermet. A cermet is a material consisting of a metal matrix with ceramic particles disseminated through it. The oxygen ions migrate through the yttria-stabilised zirconia crystal lattice of the electrolyte to oxidise the fuel. Electrons liberated at the anode pass through an external circuit to create an electrical current.

Because of the high temperatures, natural gas or other hydrocarbon fuels are reformed internally to extract the hydrogen, eliminating the need for an external reformer.

At present, fuel-to-electricity efficiencies of solid oxide fuel cells are around 50%.

However, as indicated earlier, if the hot exhaust of the cells is used in a hybrid combination with gas turbines, this is likely to approach 60%. Where the waste heat of the system is able to be used as well, overall fuel efficiencies could exceed 80-85%.

Several features of SOFC make it attractive for utility and industrial applications: high tolerance to fuel contaminants, no expensive catalysts and direct fuel processing in the fuel cells. SOFCs also have very low emissions. Because sulphur is removed from the fuel, no SO_x is emitted and since the gas-impervious electrolyte does not allow nitrogen to pass from the air electrode to the fuel electrode, the fuel is oxidised in a nitrogen-free environment, removing the possibility of NO_x emissions.

As with all fuel cells, a series array of individual cells is operated in what is known as a 'stack' (much the same as batteries) with a doped lanthanum chromite interconnect joining the anodes and cathodes of adjacent cells.

Advanced SOFCs coupled with small gas turbines with a combined rating in the range of 250kW to 25MW could eventually compete with wholesale power rates.

Protonic ceramic fuel cell-PCFC

This new type of fuel cell uses a ceramic electrolyte material that has high protonic conductivity at high temperatures. Because of the high operating temperatures, PCFCs can electrochemically oxidise fossil fuels directly to the anode, thereby eliminating the intermediate step of producing hydrogen through the expensive reforming process.

Gaseous molecules of the hydrocarbon fuel are absorbed onto the surface of the anode in the presence of water vapor, where the hydrogen atoms are stripped off and absorbed into the electrolyte, with carbon dioxide being the primary reaction product.

Because PCFCs have a solid electrolyte, the membrane cannot dry out as with PEM fuel cells and there is no liquid electrolyte to leak as with PAFCs.

Regenerative fuel cells

These are a very new member of the fuel cell family, which could be attractive as a closed-loop form of power generation, as in the Helios solar plane featured elsewhere in this issue.

Using a solar-powered electrolyser, regenerative fuel cells separate water into hydrogen and oxygen which are then fed into regenerative fuel cells, to generate electricity, heat and water. Water is then re-circulated back to the electrolyser of the regenerative fuel cell and the process repeats. These types of fuel cells are currently being researched by NASA and others worldwide.

Zinc-air fuel cells

In a typical zinc/air fuel cell, a gas diffusion electrode-cathode and a zinc anode are separated by an electrolyte and some form of mechanical separator. The gas diffusion electrode is a permeable membrane that allows atmospheric oxygen to pass through and be converted into hydroxyl ions and water. The hydroxyl ions travel through

Need power on sites without mains access? Here is Ballard Generation System's 250-kilowatt field trial stationary fuel cell power generator.

Type	Electrolyte	Ions	Operating temp.	Power generating efficiency	Reaction gas	Fuel	Features stage	Development
Alkaline AFC	alkali metal hydroxides	hydrogen"	approx 60° C	up to 70%	H_2	anhydrous ammonia	low emissions, able to use hydrogen from anhydrous ammonia	mature, used by NASA
Polymer exchange membrane PEMFC	polymer ion exchange film	hydrogen+	approx 80° C	35-45%	H_2 (max 10 ppm CO)	hydrogen, natural gas, methanol, naptha	operates at low temp, high I density used in Evs and homes	fuel stack to 10s of kW and peripherals being developed
Direct methanol DMFC	polymer ion exchange film	hydrogen+	approx 80° C	about 40%	H_2	methanol-water solution	no need for external reformer	early development but promising
Molten carbonate MCFC	carbonate	CO_3^{2-}	650° C	60% but up to 85% with cogeneration	H_2CO	natural gas, methanol, coal gas, naptha	can reform fuel internally, exhaust heat used for cogeneration	second generation fuel cells: 100kW cell under development and 1MW pilot plant performance testing underway and up to 100MW planned
Phosphoric acid PAFC	phosphoric acid	hydrogen+	approx 200° C	35-45% and more with cogeneration	H_2 (max 1% CO)	natural gas methanol	can use exhaust heat for space and water heating	mature technology, over 200 units in operation, test runs completed on 11MW plants
Solid oxide SOGC	stabilised zirconium	O_2^{2-}	approx 1000° C	45-60% with the possibility of up to 85% overall	H_2CO	natural gas, methanol, coal gas, naptha	high density, reforms fuel internally, exhaust heat used for cogeneration and turbines	cell stack to 100 kW and peripherals under development
Proton ceramic PCFC	ceramic material	hydrogen+	700° C	N/A yet	H_2	fossil fuels	electrochemical oxidization of fossil fuels at anode, solid electrolyte	still early stages

the electrolyte to the zinc anode and react with the zinc to form zinc oxide while the electrons can be used as a source of electric power.

Although the electrochemical process is similar to the PEM fuel cell, refueling is very different and is more similar to batteries. Once the zinc fuel is depleted, the system is connected to the grid and the process is reversed, leaving pure zinc fuel pellets. This reversing process takes only about five minutes to complete, so the battery recharging time is comparable to filling your fuel tank at the service station.

Tests have also been carried out on a process to regenerate the zinc oxide so that it may be reused as fuel, creating a closed-loop system in which electricity is created as zinc and oxygen are mixed in the presence of an electrolyte, creating zinc oxide.

The main advantage of zinc-air technology over batteries is its high specific energy, the key factor that determines the power potential of a battery relative to its weight. ZAFCs have been used to power electric vehicles and have delivered greater driving range than any other EV batteries of similar weight. In addition, material costs for ZAFCs and zinc-air batteries are low.

Next month, we'll look at applications and what accessories are needed to put all this wonderful potential into practical use.

SC

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Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097; or send an email to silchip@siliconchip.com.au

Why have extra holes in PC board?

I am currently working on the LP Doctor project described in the January 2001 issue and am enjoying doing it. This is a fairly complex project for me so I am proceeding very slowly and carefully. I need to ask one question however: Can you tell me what the extra drill holes are for under trimpots VR2, VR3 & VR5-VR8? There are three holes for the trimpot legs but there is another hole in the middle. They seem to be there for a purpose (particularly VR6 which connects to the 100kΩ resistor to its right) but I cannot work out their function (if any). I'm sure I have all the components in the right place. (M. P,. via email).

● The extra holes are there so that different trimpots can be fitted – just ignore them.

Display turn-off for rain gauge

I am about to build two Rain Gauges as in your June 2000 issue. One will be run on mains power while the other will be run on a 12V battery. The battery will be charged by solar power. Would it be possible to switch off the display to save power? If so, what needs to be done? (G. J., via email).

● You can switch off the supply to the display by switching the +5V supply to the emitters of Q1-Q4. You will need to cut the relevant copper track on the PC board.

Feedback on Midi-Mate interface

I built the Midi-Mate Interface for PCs described in February 2001 but found that it didn't completely work. MIDI OUT was fine but MIDI IN was not working at all.

Strangely, if I plugged my MIDI keyboard into the MIDI in and my synth into the MIDI THRU port, MIDI was being transmitted correctly from keyboard to the synth.

At this stage, I guessed that the MIDI IN was driving MIDI THRU correctly but was not able to drive the computer due to the Darlington output of the optocoupler. To fix this I added an inverter after the inverter connected to the opto output (ie, double inversion). This fixed the problem and I now have working MIDI IN, THRU and OUT. Maybe you should consider this as a modification to the circuit? (J. E., via email).

● There's no mistake with this project. We can only assume that you have a non-standard game/MIDI port input in your PC or the 6N128 optocoupler in the circuit is borderline in terms of specs.

It certainly shouldn't have been necessary to add an extra inverter.

High energy ignition for a 1968 Porsche

I have built the High Energy Ignition described in June 1998 using a Jaycar kit. I installed it on a 1968 Porsche 911S using the original distributor with points. These cars have a very marginal ignition system originally and have frequent plug fouling problems, particularly if the dwell is not set to the maximum.

The HEI module has transformed the car, making it much easier to start, allowing it to idle (ie, keep running) below 1000 RPM and most importantly, has eliminated the ignition miss above 6500 RPM (redline at 7300). The platinum plugs now last almost indefinitely even in competition use whereas a few thousand km was all I could previously expect.

Needless to say, I am extremely happy with the unit, except that I am having trouble driving the tacho. As suggested in the article, I have driven the tacho from the coil (not the Q3 output) and this works fine up to about 5500 RPM where the tacho becomes erratic (fluctuates). Given that the car is used in competition and is an ex-

Problems with the MP3 jukebox

I'm having trouble with my MP3 Jukebox project. I have a Duron 750 with 768MB RAM, 20GB HDD, running Win98 and Winamp 2.75. The Irremote program loads the playlist but only loads the first song and not the others.

I only have 40 songs in the playlist and the playlist is in the same directory as my MP3. If I add songs after the playlist loads, the title info stays on the display but the song length changes. Can help me with this problem? (W. A., via email).

- Only one track is ever displayed in Winamp's playlist – the track currently loaded by IR Remote (and displayed on the LCD). This is as we intended. Remember, the Jukebox software was designed to be used without the Windows graphical interface.

However, you should be able to move to any track in your playlist using your remote and the instructions detailed in the article. If not, then examine the information displayed in IR Remote's status window (use the UP arrow to scroll back) for possible problems loading/scanning the playlist file.

It's not possible to manually add tracks to Winamp's list while IR Remote is running. It is also important not to click on the "Shuffle" or "Repeat" buttons in Winamp, as this will confuse IR Remote.

tremely peaky engine with maximum power at about 6700 RPM, I frequently operate it in the 6000-7300 RPM range. It does have a mechanical (rotor button) ignition cutout but this is not totally reliable. Bottom line is that I need a reliable tacho. The tacho in question is the original VDO impulse tacho based on 1950s, or at the latest, early 1960s technology.

I have now built the Fig.8 auxiliary circuit as recommended but this does not drive the tacho at all. I am fairly confident that I have built it correctly and have tested it statically with a multimeter up to the base of Q2. I do not have a CRO and so I have not been able to test the output effectively but I have done a range of tests using an analog multimeter to measure AC voltage output.

Overall, I think that the problem is probably related to the shape of the waveform being generated by the output with the overall voltage contributing to some extent. Please help me with my next move. Some of the things I am considering are as follows:

(1) Use the Coil output from the High Energy Module but include a capacitor in the circuit (tacho/coil output to earth) to limit the coil voltage and modify the wave shape. However, I am concerned that this might also modify the ignition output.

(2) Use the Auxiliary circuit with a a different capacitor (not sure what) or a larger capacity coil to increase the voltage output.

(3) As a variation of the Auxiliary circuit above, use an additional coil just to drive the tacho. (This does seem overkill but should work).

(4) As another variation of the Auxiliary circuit, use the transformer as a step-up transformer to get sufficient voltage and then limit this with a capacitor and series resistors.

A second, but less important issue, is the use of a GT40 coil. I have used one for some time to get everything I can out of my ignition and I am reluctant to give away any performance unless I need to. The Jaycar notes recommend against this as it suggests that they may seriously overheat. My interpretation is that this would only occur when 12V was applied during start (ballast out of circuit) and should not be a significant problem except for prolonged cranking.

Furthermore, it should be possible to modify the various resistances (in the current limiting circuitry) to provide appropriate current limiting for the GT40 coil. Is this correct? If the only problem is a reduced life of the coil, I really don't care, as the car gets limited use and the replacement of a coil occasionally is not a problem. (B. P., via email).

- The Fig.8 circuit to drive the tacho may work if the .033µF capacitor at Q2's collector is reduced in value. Try .01µF 630V instead.

Alternatively, a 1mH RF choke may work better in place of the transformer. You could try the Jaycar LF-1546 (page 91 in their 2002 catalog).

You may also obtain a better tachometer result above 5500RPM if the zener voltage across Q1 is increased by another 75V. Try adding an extra 75V zener in series with the ZD1-ZD4 string.

You can use a high output ignition coil if you wish since reliability is not your concern.

Voltage divider for sound card output

I am trying to find a hi-low converter that will allow me to plug the speaker output of a PC sound card into the microphone input of a voice recorder without frying either of them. I need to attenuate the signal and am unable to find any product or project that will do this. It seems to be a simple and obvious thing so I'm assuming it has been done before. (R. C., via email).

- All you need is a simple resistive voltage divider to drop the audio level from the sound card to a level suitable for the microphone.

If we assume a dynamic microphone with a nominal level of 5mV and that the sound card has a nominal level of 1V (say), then you need a 200:1 voltage divider from the sound card. Use a 22kΩ resistor from the sound card and then a 100Ω resistor across the microphone input. If the resulting signal level is inadequate, increase the value of the 100Ω resistor.

Increasing reluctor sensitivity for ignition

I have completed assembly of the Universal High Energy Ignition as described in the June 1998 issue of SILICON CHIP but I cannot get the system to trigger at cranking speed. The system triggers when spun by hand at slightly higher speed. The circuit is built for a reluctor to suit a 1984 Toyota Corolla. As a further test, I have tried a Mitsubishi Sigma distributor which also has the same problem.

The air gaps and trigger polarities have been altered without success. As a last resort, I modified another kit which has been running in an early Commodore on a points circuit but still no luck! Any suggestions would be much appreciated. (D. H., via email).

- You can increase sensitivity of the

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reluctor circuit by changing the 47kΩ resistor connecting to the cathode of zener diode ZD5. Making this value larger will improve sensitivity. Try a value between 47kΩ and 100kΩ or use a trimpot (say 200kΩ) and adjust it until the circuit works. Then select a fixed resistor that is close to the trimpot resistance.

Mighty Midget needs low resistance cables

I constructed the Mighty Midget power amplifier from the March 2002 issue. It operates as it should except it has a slight problem.

When the Bass control is turned into the boost region, the speaker cones (both channels) exhibit a large excursion once every three to four seconds; the current drawn at this point is about 2.5A. This was observed using both a 10A power supply and a car battery. The speakers used were 4-inch, 4-ohm dual cone speakers. All component values and connections have been checked. Seeking enlightenment. (P. L., via email).

● The problem is "motor-boating" and is caused by inadequate power supply leads. You need lower resistance power supply cables. Use 4mm auto wire or thicker; the more copper the better.

Increasing Woofer Stopper output

I have just completed a Woofer Stopper Mk2 (February 1996) successfully but now I want to increase output of this project. I have only one piezo tweeter (KSN 1005A) connected at present but the effect on the dogs doesn't seem to be enough. Should I be considering the KSN 1177A TD?

● The output from the Woofer Stopper is very dependent on the piezo drive. So the KSN1177 twin tweeter which produces 99dB for 2.83V compared to the 1005A at 94dB for 2.83V in will produce much more sound. Paralleling up a few will also increase sound levels. **SC**

Notes & Errata

Sooper Snooper, September 2001: depending on whether the Snooper circuit is built for electret microphone, dynamic microphone or RF pickup, the 4.7kΩ resistor should be included or omitted, as indicated in the article. However, if the 4.7kΩ resistor is included, the 1μF capacitor should have its negative side connected to the base of Q1.

If the 4.7kΩ resistor is omitted, the 1μF capacitor should have its positive electrode connected to the base of Q1, as shown on circuit but incorrectly shown on the wiring diagram. Alternatively, fit a non-polarised 1μF capacitor instead.

Audio/Video Distribution Amplifier, November 2001: as presented, the audio stages have a gain of two which will result in excessive audio level with some CDs and DVDs. To restore the gain to unity, remove the 100kΩ feedback resistor from pins 2 & 6 to the 0V line. This makes the op amps in IC2 operate as voltage followers, with unity gain.

LP Doctor, January & February 2001: in the text on page 28 of the January issue, the final sentence in the second last paragraph refers to IC5a providing a gentle treble cut at 12dB/octave above 10kHz. Instead it should refer to IC5b (and IC7b).

The overlay diagram on page 78 of the February issue shows two trimpots numbered VR8. VR8 shown near IC14 should be VR7. The test procedure (3) on page 82 should read "Monitor Test Point TP4 and adjust VR7 for a 0mV reading." (Not VR8).

Table 3 on page 80 of the February issue should have the heading "How To Set Different Delays For IC3 and IC7 using Linking on IC20" (not delays for IC2 using IC8).

Stepper Motor Controller, May 2002: on the circuit diagram on page 77 most of the earth symbols and one resistor failed to print. The "hole" alongside VR1, labelled 10kΩ, should have a resistor occupying it, while all nine of the vertical lines which end with nothing should go to earth (GND).

Mighty Midget 70W Amplifier Module, March 2002: this amplifier is very sensitive to dips in the supply voltage and will mute if it goes below about 7V. This may not seem likely but peak currents can be as high as 9A and with thin supply cables, the amplifier will repeatedly mute which can sound like motor-boating.

The cure is to use heavy-duty cable. We suggest 4mm auto cable as a minimum.

6-Channel IR Remote Volume Control, March & April 2002: the 33Ω 5W resistor in the power supply should be 330Ω 5W. This can be seen in the photos on page 64 of the March issue and page 72 of the April issue.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely. Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine. Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

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This book is for anyone involved in designing, adapting and using analog and digital audio equipment. It covers tape recording, tuners and radio receivers, preamplifiers, voltage amplifiers, audio power amplifiers, compact disc technology and digital audio, test and measurement, loudspeaker crossover systems, power supplies and noise reduction systems. 375 pages in soft cover.

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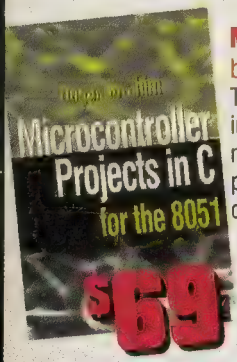

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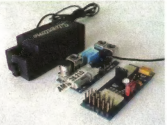

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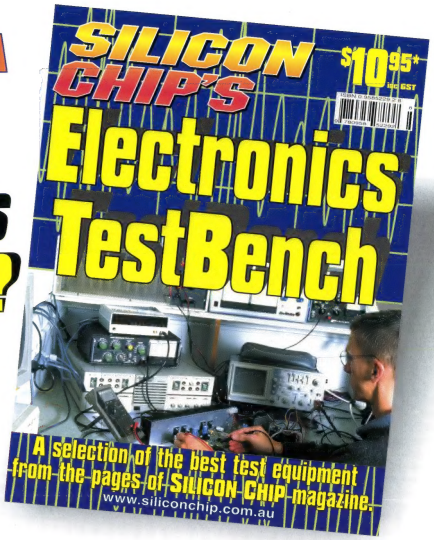

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